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Environmental Impact Guidelines for New Source Petroleum Refineries

WAPORA, Inc.
Washington, DC

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Environmental Impact Guidelines

For New Source Petroleum Refineries

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16. ABSTRACT

This guideline document has been prepared to augment the information previously released by the Office of Federal Activities entitled Environmental Impact Assessment Guidelines for Selected New Source Industries. Its purpose is to provide guidance for the preparation and/or review of environmental documents (Environmental Information Document or Environmental Impact Statement) which EPA may require under the authority of the National Environmental Policy Act (NEPA) as part of the new source (NPDES) permit application review process.

This document has been prepared in seven sections, organized in a manner to facilitate analysis of the various facets of the environmental review process. The initial section includes a broad overview of the industry intended to familiarize the audience with the processes, trends, impacts and applicable pollution regulations commonly encountered in the petroleum refining industry. Succeeding sections provide a comprehensive identification and analysis of potential environmental impacts, pollution control technologies available to meet Federal standards, and other controlable impacts. The document concludes with three sections: available alternatives a listing of Federal regulations (other than pollution control) which may apply to the new source applicant, and a comprehensive listing of references for further reading.

17. KEY WORDS AND DOCUMENT ANALYSIS

a. DESCRIPTORS	b. IDENTIFIERS/OPEN ENDED TERMS	c. COSATI Field/Group
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ENVIRONMENTAL IMPACT GUIDELINES
FOR NEW SOURCE
PETROLEUM REFINERIES

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US Environmental Protection Agency
Office of Federal Activities
Washington, D.C. 20460

1-a

Preface

This document is one of a series of industry-specific Environmental Impact Guidelines being developed by the Office of Federal Activities (OFA) for use in EPA's Environmental Impact Statement preparation program for new source NPDES permits. It is to be used in conjunction with Environmental Impact Assessment Guidelines for Selected New Source Industries, an OFA publication that includes a description of impacts common to most industrial sources.

The requirement for Federal agencies to assess the environmental impacts of their proposed actions is included in Section 102 of the National Environmental Policy Act of 1969 (NEPA), as amended. The stipulation that EPA's issuance of a new source NPDES permit as an action subject to NEPA is in Section 511(c)(1) of the Clean Water Act of 1977. EPA's regulations for preparation of Environmental Impact Statements are in Part 6 of Title 40 of the Code of Federal Regulations; new source requirements are in Subpart F of that Part.

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INTRODUCTION

The Clean Water Act requires that EPA establish standards of performance for categories of new source industrial wastewater dischargers. Before the discharge of any pollutant to the navigable waters of the United States from a new source in an industrial category for which performance standards have been proposed, a new source National Pollutant Discharge Elimination System (NPDES) permit must be obtained from either EPA or the State (whichever is the administering authority for the State in which the discharge is proposed). The Clean Water Act also requires that the issuance of a permit by EPA for a new source discharge be subject to the National Environmental Policy Act (NEPA), which may require preparation of an Environmental Impact Statement (EIS) on the new source. The procedure established by EPA regulations (40 CFR 6 Subpart F) for applying NEPA to the issuance of new source NPDES permits may require preparation of an Environmental Information Document (EID) by the permit applicant. Each EID is submitted to EPA and reviewed to determine if there are potentially significant effects on the quality of the human environment resulting from construction and operation of the new source. If there are, EPA publishes an EIS on the action of issuing the permit.

The purpose of these guidelines is to provide industry-specific guidance to EPA personnel responsible for determining the scope and content of EID's and for reviewing them after submission to EPA. It is to serve as supplementary information to EPA's previously published document, Environmental Impact Assessment Guidelines for Selected New Source Industries, which includes the general format for an EID and those impact assessment considerations common to all or most industries. It also includes Appendix B-2 which covers the petroleum refining industry. Both that document and these guidelines should be used for development of an EID for a new source petroleum refinery.

These guidelines provide the reader with an indication of the nature of the potential impacts on the environment and the surrounding region from construction and operation of petroleum refineries. In this capacity, the volume is intended to assist EPA personnel in the identification of those impact areas that should be addressed in an EID. In addition, the guidelines present (in Chapter I) a description of the industry, its principal processes, environmental problems, and recent trends in location, raw materials, processes, pollution control and the demand for industry output. This "Overview of the Industry" is included to familiarize EPA staff with existing conditions in the industry.

Although this document may be transmitted to an applicant for informational purposes, it should not be construed as representing the procedural requirements for obtaining an NPDES permit or as representing the applicant's total responsibilities relating to the new source EIS program. In addition, the content of an EID for a specific new source applicant is determined by EPA in accordance with Section 6.604(b) Title 40 of the Code of Federal Regulations and this document does not supersede any directive received by the applicant from EPA's office responsible for implementing that regulation.

The guideline is divided into six sections. Chapter I is the "Overview of the Industry," described above. Chapter II, "Impact Identification, discusses process-related wastes and the impacts that may occur during construction and operation of the facility. Chapter III, "Pollution Control," decribes the technology for controlling environmental impacts. Chapter IV discusses other impacts that can be mitigated through design considerations and proper site and facility planning. Chapter V, "Evaluation of Alternatives," discusses the consideration and impact assessment of possible alternatives to the proposed action. Chapter VI, describes regulations other than pollution control that apply to the industry.

I. OVERVIEW OF THE PETROLEUM REFINING INDUSTRY

Standard Industrial Classification (SIC) Code 2911 defines a petroleum refinery as a complex combination of interdependent operations engaged in the separation of crude oil by molecular cracking, molecular rebuilding and solvent finishing to produce a varied list of intermediate and finished products that include gasoline, jet fuel, fuel oil, "lube" oil*, grease, asphalt, coke and wax among others. About 120 companies are engaged in petroleum refining in the United States.

As of January 1978 there were 285 operating refineries in the US with a daily production capacity of approximately 16.9 million barrels per calendar day (B/CD). About 55% of these or 158 were constructed between 1944 and 1970. Production capacity ranges from 150 B/CD to 640,000 B/CD. More than one-third of US refineries have a capacity of less than 10,000 barrels per day, but together these refineries account for only 2.5% of the total capacity of the industry. Refineries with a rated daily capacity greater than 150,000 barrels, make up about 9% of the total number of US refineries and account for about 43% of the total industry capacity. Total annual employment for the industry is approximately 140,000, and total industry-wide sales for domestically consumed petroleum products were estimated to be $40 billion in 1978. The state of Texas has the highest concentration of refineries; the 53 facilities there make up 18.8% of the national total. California has 40 refineries, and Louisiana, Illinois, Kansas, Oklahoma, Pennsylvania, and Wyoming have 10 or more each. Refining capacity of individual states roughly parallels the number of facilities.

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*See Glossary for discussion of technical terms

I.A. SUBCATEGORIZATION

The processes by which crude oil is manufactured into a multitude of products are numerous and complex. Crude oils from different sources themselves vary importantly, and refineries are often designed especially to process crude from a particular source. Refineries also differ widely not only in size but in the number and sophistication of the processes they employ and the variety of products they produce. While some can produce a wide range of items, from fuel gas and LPG through gasoline and olefins to greases, asphalt and coke, the simpler operations of others may limit their output to a few items such as fuel gas, gasoline blending stocks and heavy fuel oil.

In order to classify refineries for the purpose of setting standards for limitations on effluents that may be discharged and establishing new source performance standards (i.e. effluent standards for new refineries), EPA has subcategorized refineries by processes employed. This approach is practical because raw waste load characteristics are related to process complexity rather than of capacity.

A description of the separate subcategories and a numerical distribution of petroleum refineries by subcategory (1976 data) are presented in Tables 1 and 2, respectively. Processes named in the tables are discussed in the following section.

I.B. PROCESSES

The key components of various refinery processes and their capacities are described in this section and process flow diagrams are provided to indicate the different levels of sophistication in refinery processes. Definitions of technical terms may be found in the glossary at the end of this report.

Crude oil consists of a large number of separate organic compounds whose properties are primarily dependent on the number of carbon atoms that they contain. Increasing numbers of carbon atoms result in higher boiling points, and the first step in the refining process is to separate the crude by distillation into several fractions according to boiling point range. The highest boiling fraction, which exists as a gas at normal conditions, consists of methane, having a single carbon atom, as well as molecules ranging from 2 to 4 carbon atoms. These components of the first, or gas fraction are used as fuel gas, LPG (liquified petroleum gases, mainly propane and butane), and as building blocks in petrochemical processes. The next higher-boiling fractions, called naphtha and kerosene, are used in the production of gasolines and jet fuels, and contain components in a range centering around 7 carbon atoms. The next higher-boiling fraction, middle distallates, is the stock from which diesel and light fuel oils are made. The still higher boiling fractions become the heavier fuel oils and lubricating oils.

While some of these initial fractions, e.g. heavy fuel oil, may be satisfactory as final products, most require additional processing. This may be further separation, solvent finishing, or reforming in the presence of a catalyst. Or it may involve the second and third major refinery processes -- cracking, and conversion or reconstruction. In these, the fractions are converted to saleable products by cracking (i.e., splitting their molecules) then

Table 1. Subcategorization of the petroleum refining industry.

Subcategory	Basic Refinery Operations Included
Topping	Topping and catalytic reforming whether or not the facility includes any other process in addition to topping and catalytic reforming. This subcategory is not applicable to facilities which include thermal processes (coking, visbreaking, etc.) or catalytic cracking.
Cracking	Topping and cracking whether or not the facility includes any processes in addition to topping and cracking, unless specified in one of the subcategories listed below.
Petrochemical	Topping, cracking, and petrochemical operations[1] whether or not the facility includes any process in addition to topping, cracking, and petrochemical operations except lube oil manufacturing operations.
Lube	Topping, cracking, and lube oil manufacturing processes whether or not the facility includes any process in addition to topping, cracking, and lube oil manufacturing processes except petrochemical and integrated operations.
Integrated	Topping, cracking, lube oil manufacturing, and petrochemical operations whether or not the facility includes any processes in addition to topping, cracking, lube oil manufacturing, and petrochemical operations.

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[1] The term "petrochemical operations" means the production of second generation petrochemicals, i.e., alcohols, ketones, cumene, styrene, etc., or first generation petrochemicals and isomerization products, i.e., BTX, olefins, cyclohexane, etc., when 15% or more of refinery production is as first generation petrochemicals and isomerization products. Owing to the diversity and complexity of the petrochemical processes and associated impacts, this subcategory will be the subject of a separate appendix. It is included here because it is an official subcategory of the petroleum refining industry.

Source: U.S. EPA. 1977. Interim final supplement for pretreatment to the development document for the petroleum refining industry. Existing point source category EPA 440/1-76/083A.

Table 2. Numerical distribution of petroleum refineries by subcategory (data from 1976).

Subcategory	Indirect Dischargers		Total Industry	
	#	% of total	#	% of total
A - Topping	10	38	96	38
B - Cracking	13	50	111	43
C - Petrochemical	2	8	19	7
D - Lube	0	0	22	9
E - Integrated	1	4	8	3

Sources: Contrell, Aileen. 1976. Annual refining survey. The Oil and Gas Journal, 29 March, pp. 125-152.

National Commission on Water Quality. 1975. Petroleum refining industry, technology and costs of wastewater control. Prepared by Engineering Science, Inc.

rearranging the molecular structure. Middle distillate and fuel oil fractions are often processed to break them up into smaller components (cracking) to increase the yield of gasolines and other light products. The heavy residues can be used directly as residual fuel oils, or processed to give lighter fractions.

Most products require treatment to remove, or inhibit activity by undesirable components. Lastly, refined base stocks, blended with each other and with various additives, are developed into useful products.

Figures 1,2 and 3 show the processing plans for typical minimal, intermediate and complete petroleum refineries respectively. "Topping," that is, separation of the crude by distillation, is the first step for all. Simple refineries (Figure 1) separate the crude and perform limited treating. Immediate refineries (Figure 2) use catalytic or thermal cracking, catalytic reforming, and additional treating to produce the gasolines and LPG not produced in the simple refineries and also to manufacture heavy products such as lube (lubricating) oils and asphalt. Complete large refineries distill and crack the crude oil, treat process gas, upgrade gasoline by catalytic reforming, alkylation, and isomerization, and manufacture lube oils, asphalts, and waxes (Figure 3).

Auxiliary systems perform other functions in petroleum refineries. Examples of these are: supplementary treatment units to purify both liquid and gas streams; waste management and pollution control systems; cooling water systems; units to recover hydrogen sulfide (H_2S) from gas streams and to convert it into elemental sulfur or sulfuric acid; electric power support stations; steam-producing facilities; and storage and handling of crude oil and by-products.

Description of the processes involved in the production of one type of fuel product will illustrate the nature of complex refinery operations and the nature of the problems that relate to refinery effluents. The following discussion therefore focuses on the basic unit processes for the manufacture of fuel products in the US refinery industry[1]. Discussions of operations for the manufacture of lubricating oils, waxes, solvents, road oils, asphalt, petrochemicals, and other nonfuel products may be found in Hobson et al (1973) and other references.

The three basic functions performed by most refineries, and the basic unit processes by which they may be accomplished in the manufacture of fuels are as follows:

Separation of the various components or crude oil by boiling point
- -- Distillation or fractionation

Splitting large molecules into smaller ones
- -- Catalytic cracking
- -- Catalytic hydrocracking
- -- Thermal cracking

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[1] Outside the US the use of gasoline-creating processes e.g. catalytic cracking, alkylation and catalytic hydrocracking (in refineries) is less common.

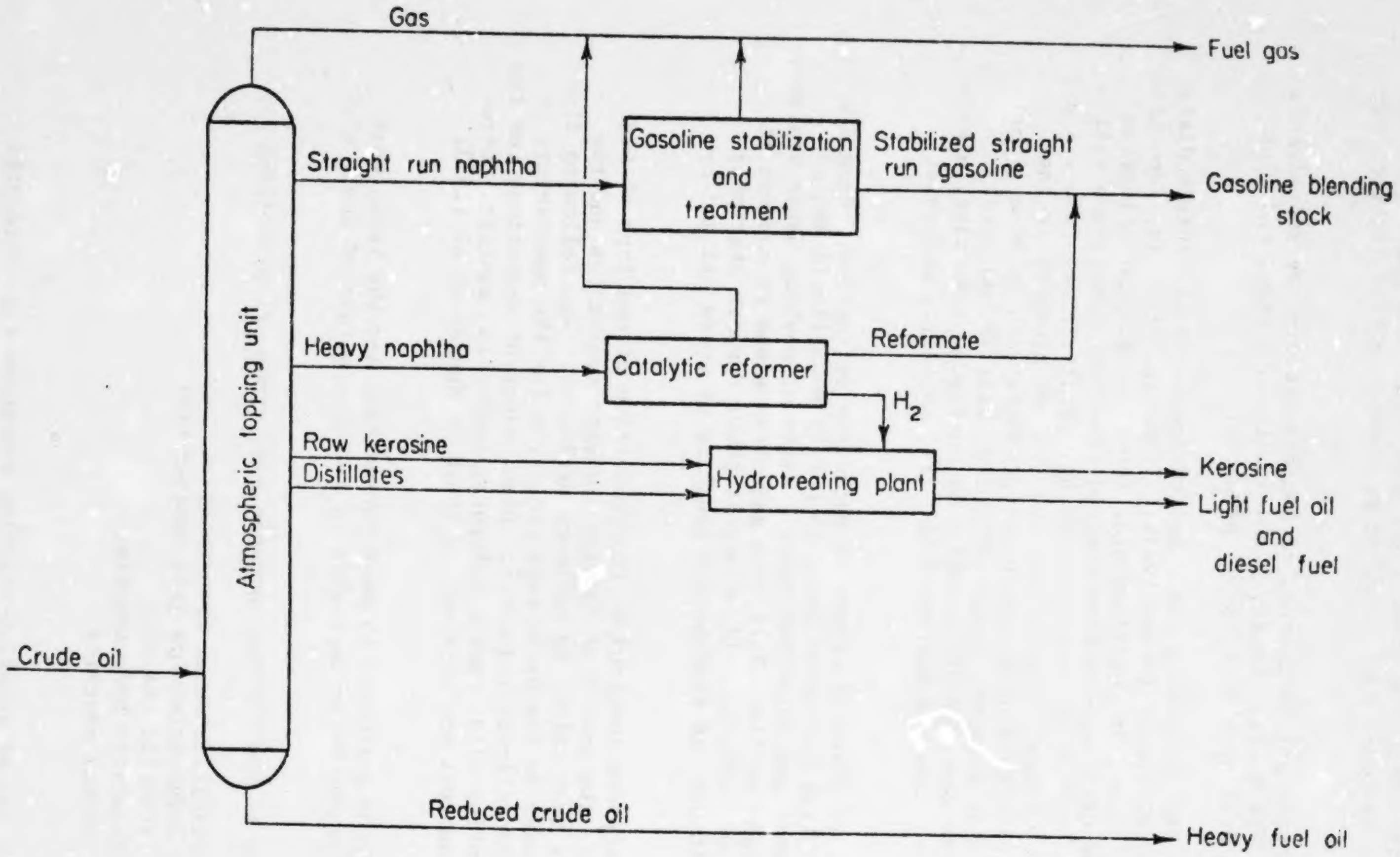

Gas
Fuel gas
Straight run naphtha
Gasoline stabilization and treatment
Stabilized straight run gasoline
Gasoline blending stock
Atmospheric topping unit
Heavy naphtha
Catalytic reformer
Reformate
H_2
Raw kerosine
Distillates
Hydrotreating plant
Kerosine
Light fuel oil and diesel fuel
Crude oil
Reduced crude oil
Heavy fuel oil

Figure 1. Processing plan for typical minimal refinery.

Source: U.S. EPA. 1972. Evaluation of waste waters from petroleum and coal processing. Office of Research and Monitoring. R2-72-001. Washington DC.

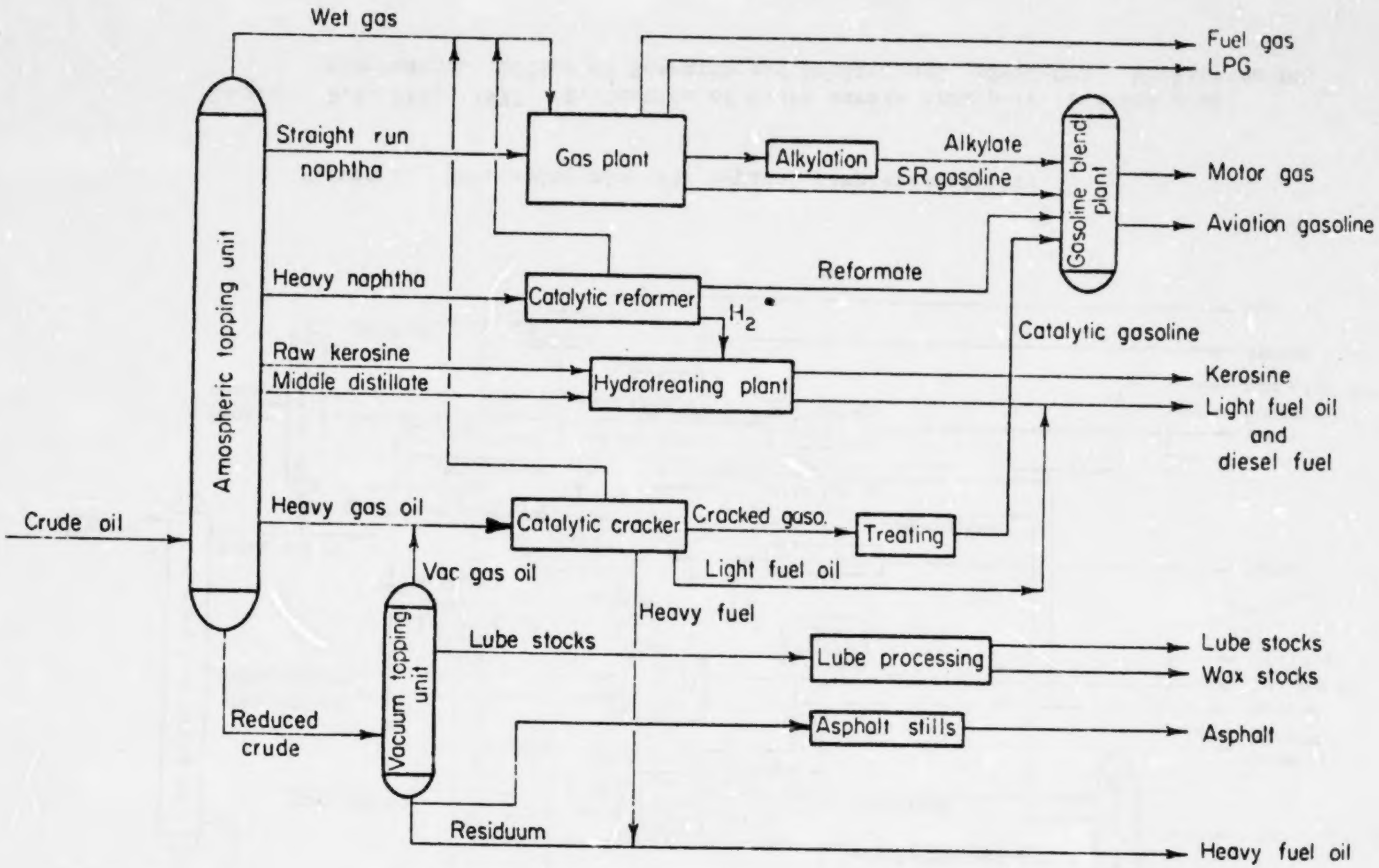

Wet gas
Crude oil
Amosphepric topping unit
Straight run naphtha
Heavy naphtha
Raw kerosine
Middle distillate
Heavy gas oil
Reduced crude
Vac gas oil
Vacuum topping unit
Residuum
Lube stocks
Heavy fuel
Gas plant
Alkylation
Alkylate
SR gasoline
Catalytic reformer
H_2
Reformate
Hydrotreating plant
Catalytic cracker
Cracked gaso.
Treating
Light fuel oil
Catalytic gasoline
Gasoline blend plant
Lube processing
Asphalt stills
Fuel gas
LPG
Motor gas
Aviation gasoline
Kerosine
Light fuel oil and diesel fuel
Lube stocks
Wax stocks
Asphalt
Heavy fuel oil

Figure 2. Processing plan for typical intermediate refinery.

Source: U.S. EPA. 1972. Evaluation of waste waters from petroleum and coal processing. Office of Research and Monitoring. R2-72-001. Washington DC.

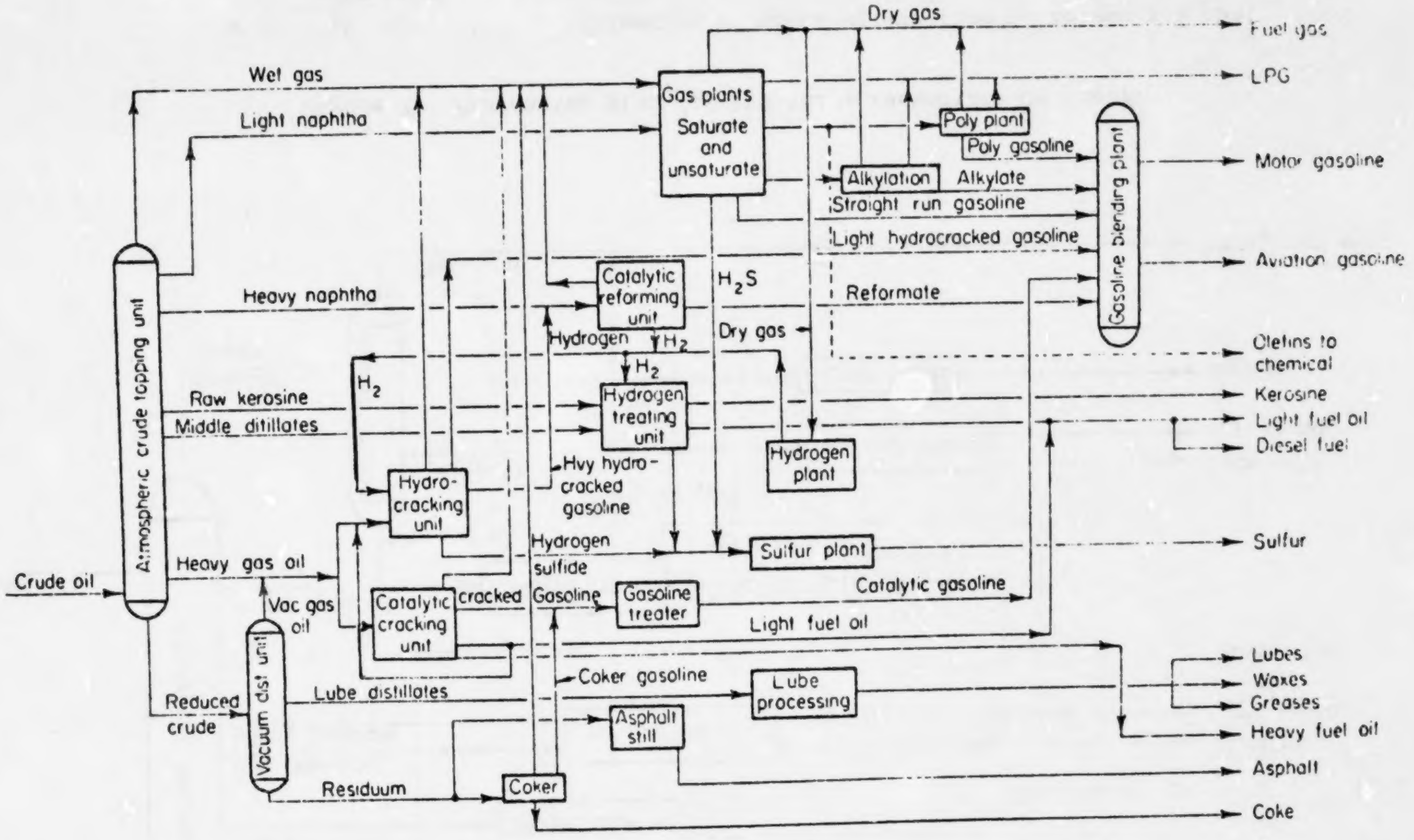

Crude oil
Atmospheric crude topping unit
Wet gas
Light naphtha
Heavy naphtha
Raw kerosine
Middle ditillates
Heavy gas oil
Reduced crude
Vacuum dist unit
Vac gas oil
Lube distillates
Residuum
H_2
Hydro-cracking unit
Catalytic cracking unit
cracked
Coker
Catalytic reforming unit
Hydrogen
H_2
H_2
Hydrogen treating unit
Hvy hydro-cracked gasoline
Hydrogen sulfide
Gasoline
Gasoline treater
Coker gasoline
Asphalt still
Gas plants Saturate and unsaturate
H_2S
Dry gas
Hydrogen plant
Sulfur plant
Lube processing
Dry gas
Poly plant
Poly gasoline
Alkylation
Alkylate
Straight run gasoline
Light hydrocracked gasoline
Reformate
Catalytic gasoline
Light fuel oil
Gasoline blending plant
Fuel gas
LPG
Motor gasoline
Aviation gasoline
Olefins to chemical
Kerosine
Light fuel oil
Diesel fuel
Sulfur
Lubes
Waxes
Greases
Heavy fuel oil
Asphalt
Coke

Figure 3. Processing plan for typical complete refinery.

Source: U.S. EPA. 1972. Evaluation of waste waters from petroleum and coal processing. Office of Research and Monitoring. R2-72-001. Washington DC.

Reconstruction of molecules
- -- Hydrotreating
- -- Alkylation
- -- Polymerization
- -- Isomerization
- -- Reforming

Treating
- -- Gas concentration
- -- Solvent refining

The descriptions below focus on the basic function of the aforementioned unit processes and the relationships between them.

I.B.1. Desalting of Crude Oil

Crude oil frequently contains brine from underground deposits. To minimize corrosion of refining equipment, the crude is usually put through a desalter, which reduces the inorganic salt content of the oil before it enters the distillation unit. This brine is removed in settling towers, usually at elevated temperatures 90 - 145°C (200 - 300°F) and at elevated pressures 3.4 - 17 atmospheres (50 - 250 pounds per square inch). The towers are packed with sand, gravel, or excelsior. Caustic is sometimes added to adjust pH. In other cases, an electrical field (16,500 - 33,000 volts) is applied across the vessel to cause droplets to coalesce more rapidly. Chemicals (modified fatty acids, partly wholly saponified with ammonia, oil-soluble petroleum sulfonate, water-soluble solvents, oil-soluble solvents or inorganic sulfates) are used to improve the efficiency of desalting.

Salt concentrations in raw crude oil vary widely, from nearly zero to hundreds of kilograms of sodium chloride (NaCl) per 1,000 bbl. The salt removed from the crude are usually an important waste product.

I.B.2. Crude Oil Distillation

Distillation is the process of producing a gas or vapor from a liquid by heating the liquid in a vessel and collecting and condensing the vapors into liquids. In a petroleum refinery it is a method of separation. The crude oil is distilled at the lowest boiling point and the distillate is collected as one fraction. As the next high-boiling component begins to distill, it is then collected as a separate fraction, and the process, sometimes called "fractional distillation," continues. The fractions are then processed appropriately in later stages to make specific products.

The term "fractionation" means separation of a mixture in successive stages, each stage removing from the mixture some proportion of one of the substances, as by distillation, or by differential solubility in water-solvent mixtures.

"Topping" refers to the distillation of crude petroleum to remove the light fractions only. However, the crude distillation unit in a refinery is called the "topping unit."

In the atmospheric pressure distillation section of the unit, the crude oil is heated to a temperature at which it is partially vaporized and then introduced near, but at some distance above, the bottom of a distillation column. This cylindrical vessel is equipped with numerous trays through which hydrocarbon vapors can pass in an upward direction. Each tray contains a layer of liquid through which the vapors can bubble upward and the liquid can flow continuously by gravity in a downward direction from one tray to the next one below. As the vapors pass upward through the succession of trays, they become lighter (lower in molecular weight and more volatile) and the liquid flowing downward becomes progressively heavier (higher in molecular weight and less volatile).

The countercurrent action results in fractional distillation, or separation, of hydrocarbons based on their boiling points. A liquid can be withdrawn from any preselected tray as a net product -- the heavier liquids, e.g., diesel oil, from the trays near the bottom. The boiling range of the net product liquid corresponds to the tray from which it is taken. Vapors which contain the C_6 and lighter hydrocarbons are withdrawn from the top of the column as a product, and a liquid stream with a temperature of about 343°C (650°F) is removed from the bottom of the crude distillation column. This bottom liquid stream, called the atmospheric residue, is heater further and introduced into a vacuum column operated at an absolute pressure close to 50 mm Hg (atmospheric pressure is 760 mm Hg) maintained by the use of steam ejectors. In this vacuum column, a flash separation is made to produce the heavy gas oil and the nondistillable pitch products. Although the vacuum column contains certain internal hardware to minimize the entrainment of pitch in the rising vapors and to aid in transfer of heat between vapor and liquid, it is more accurately better described as a chamber in which vapor and liquid are separated by a single-stage flash than as a fractional-distillation column.

The crude oil and atmospheric residue are brought to their desired temperatures in tubular heaters. Oil is pumped through the inside of the tubes contained in a refractory combustion chamber fired with oil or fuel gas in such manner that heat is transferred through the tube wall in part by convection from hot combustion gases and in part by radiation from the incandescent refractory surfaces.

A typical topping unit will resolve the crude into the following fractions:

By distillation at atmospheric pressure
-- A light straight-run fraction (gasoline blending stock), primarily consisting of the C_5 and C_6 hydrocarbons, but also containing the C_4 and lighter hydrocarbons, which are routed to a central gas-concentration unit for further resolution. The stabilized C_5/C_6 blend usually contains odorous mercaptans, which normally are treated for odor improvement before delivery to the refinery gasoline pool.
-- A naphtha (kerosene) fraction having a nominal boiling range of 93 - 204°C (200 - 400°F)
-- A light fuel oil distillate with boiling range of 204 - 343°C (400 - 650°F);

By vacuum flashing
-- Heavy fuel oil having a boiling range of 343 - 566°C (650 - 1050°F)
-- A nondistillable residual pitch

Of the components in modern gasoline pools the light straight-run fraction has the lowest octane number (anti-knock rating). Its unleaded octane number, in a typical case, will be just under 70, and the unleaded octane number for the entire refinery pool (based on US average) will be about 89. The light straight-run fraction has a good octane number response to additions of lead alkyls.

I.B.3. Reforming

Reforming is the rearranging in the presence of a catalyst of hydrocarbon molecules in a gasoline boiling-range feedstock to form hydrocarbons having a higher antiknock quality.

In order to raise the octane rating of the heavy naphtha fraction (Figure 1) (which varies with the crude source but which normally ranges from 40 to 50) so that it will be a suitable component for blending into finished gasoline pools, the chemical composition of the fraction must be changed. This is usually accomplished by catalytic reforming.

It should be noted that practically all naphtha stocks fed to catalytic reforming units are hydrotreated to remove or inactivate arsenic, sulfur and nitrogen compounds that would deactivate the catalyst.

The resulting naphtha, called reformate, is then fed into the gasoline blending pool.

Byproducts of this process include hydrogen, which is used in hydrotreating and whenever hydrocracking may be practiced in the refinery.

Reforming of natural gas or light naphtha fractions with steam also produce hydrogen.

I.B.4. Catalytic Cracking

Catalytic cracking is the conversion of high-boiling hydrocarbons into lower-boiling types by a catalyst.

A distilled gas-oil charge is fed at elevated temperatures from 460 - 515°C (860 - 955°F) in a catalyst bed (usually silica-alumina) in which the feed is converted to simpler hydrocarbons usually of a higher octane number. Light olefin is usually produced as a byproduct. The catalyst arrangement (fixed bed, fluid bed, multiple bed, single bed, etc.) varies but the catalyst is always regenerated.

The primary function of catalytic cracking is to convert into gasoline those fractions having boiling ranges higher than that of gasoline which after treatment for odor control, are blended with other gasoline stocks. An important secondary function is to create light olefins such as propylene and butylenes, to be used as feedstocks for motor-fuel alkylation and petrochemical production. Although the principal feedstock is the gas oil separated from the crude by distillation, this feed often is supplemented with light distillates and with distillate fractions which result from thermal coking operations.

For practical reasons, the cracking of distillate feedstock to lighter materials is not carried to completion. The remaining, uncracked distillates (cycle oils) are usually used as components for domestic heating fuels (generally after hydrotreating) and to blend with residual fractions to reduce their viscosity to make acceptable heavy fuel oil. In some refineries, however, cycle oils are hydrocracked to complete their conversion to gasoline.

The principal products then, are gasolines, whose unleaded octane numbers range from 89 to 93, and light olefins. Another product is isobutane, a necessary reactant for the alkylation process.

I.B.5. Hydrocracking

In a sense, hydrocracking is complementary and supplementary to catalytic cracking because hydrocracking occurs over a catalyst in a hydrogen environment with heavy distillates and, in some cases, with cycle oils which are impractical to convert completely in catalytic cracking units. The purpose of hydrocracking is to produce additional gasoline stock from heavy materials. The process also takes place at lower temperatures and higher pressures than fluid catalytic cracking. Generally, the C_5-C_6 fraction is blended into the gasoline pool and occasionally the heavier portion of the gasoline also is blended into the gasoline pool although the primary products are gasoline or jet fuels and other light distillates. An important secondary product is isobutane. Sometimes this portion is reformed first, to improve its octane number. Figure 3 shows only heavy gas oil as a feedstock, and in the figure the entire liquid product as gasoline is routed directly to the refinery gasoline pool even though the aforementioned options are performed widely in various combinations.

I.B.6. Thermal Cracking

The heavy fractions, as produced by most vacuum-flashing units, are too viscous to be marketed as a heavy fuel oil without further treatment. In some refineries the pitch processing in a thermal cracking unit (visbreaking) at relatively low temperatures and short contact times will reduce its viscosity sufficiently. Additional viscosity reduction is obtained by blending in catalytically produced oil to produce marketable residual fuel oil.

In certain situations it is more economical to process the pitch in a thermal coking unit from which the main products are gasoline, distillates, and coke. The gasoline from a coking unit is handled as previously described. The coke can be used, after calcination, for electrode manufacture where it meets certain purity specifications, but the coke is used principally as a metallurgical coke or fuel. Distillates from thermal coking operations may be used as feedstock for catalytic cracking or the lighter distillates may be routed to the refinery distillate produce pool hydrotreatment.

A few refiners obtain additional feedstock for catalytic cracking or hydrocracking operations by solvent extraction of the vacuum pitch, usually with propane as the solvent. The extract is relatively free of organometallic compounds and highly condensed aromatic structures hydrocarbons which are difficult to crack. Thus, the extract is suitable for handling by catalytic units. Extracted pitch is processed subsequently in thermal units or converted to asphalts.

The small amount of thermal gasoline which is made as a byproduct is routed after treatment to the gasoline pool or to catalytic reforming through a hydrotreating unit because its octane number is relatively low.

I.B.7. Hydrotreating

As a processing tool hydrotreating has numerous applications in a refinery, where its principal function is to saturate olefins and convert oxygen, sulfur and nitrogen to compounds that can be removed. It also converts other impurities such as arsenic to more easily removable compounds. The process employs hydrogen and a catalyst. The use of hydrotreating for pretreating naphthas prior to catalytic reforming has been already mentioned.

Figure 3 shows hydrotreatment of the crude light distillate (kerosine middle distillate) and the catlytic cycle oil in a single block before being routed to the refinery light distillate pool. Occasionally the light distillate in the crude may be sufficiently low in sulfur content to bypass hydrotreating; usually, however, part of the stream must be hydrotreated to remove native sulfur compounds. Some refineries hydrotreat parts of their catalytic cracking feeds, particularly if they originate from thermal operations or if they are inordinately high in sulfur content.

Desulfurization is also an objective in the production of low sulfur residual fuel oils. Sulfur content of reduced crudes (>4%) can be reduced to about 1% by vacuum flashing, hydrodesulfurizing the overhead vacuum-distilled gas oil, and blending the gas oil of low sulfur content with the untreated pitch to obtain a reconstituted low-sulfur fuel oil.

I.B.8. Gas Concentration

The gas concentration system (Figure 3) collects gaseous product streams from various processing units and physically separates the components to provide, usually, a C_3/C_4 stream as a feedstock for alkylation and a C_2 and lighter stream that largely is used to supply process heat (requirements) for the refinery.

Hydrogen sulfide is removed from gas streams in which it occurs by selective absorption in liquid solutions (usually organic amines). The H_2S released from the rich solution is converted by further processing into elemental sulfur or H_2SO_4 (sulfuric acid).

I.B.9. Alkylation

In motor fuel refineries the alkylation units produce a high quality paraffinic gasoline by the chemical combination of isobutane with propylene and/or butylenes. A small amount of pentenes is also alkylated. The alkylation is accomplished with the catalytic aid of hydrofluoric (HF) or sulfuric acid (H_2SO_4) to produce a gasoline with octane numbers that range from 93 to 95.

Propane and n-butane associated with the olefins in the feedstocks are withdrawn from alkylation units as byproducts. Part of the n-butane is routed to the gasoline pool to adjust the vapor pressure of the gasoline to a level which permits prompt and easy starting of engines. The remainder of the n-butane and the propane is available for liquified petroleum gas (LPG), a clean fuel that easily is distributed as bottled gas for heating purposes.

I.B.10. Polymerization

Polymerization, in an oil refinery, involves the combination of small molecules (i.e., ethylene) into somewhat larger compounds (C_6 and higher) including cyclic compounds such as benzene and tolune.

Polymerization may be carried out thermally in the vapor phase at 510-595°C (950-1100°F) for extended periods of time. Reaction pressures are about 170 atmospheres (2500 psig) with a yield of 62 - 72% by weight.

Catalytic polymerization is carried by in the presence of phosphoric acid or other catalysts (silica - alumina, aluminum chloride, boron triflouride and activated bauxite). Phosphoric acid is used in three forms (quartz wetted with liquid acid, acid-impregnated pellets and solid catalyst pellets) packed in tubes surrounded with cooling water. This process operates at pressures of 17-60 atmospheres (250-900 psig) and temperatures of 155-230°C (310-450°F).

I.B.11. Isomerization

In this process, normal parafinns are converted to branched chain paraffins in order to produce higher octane gasoline. Aluminum chloride is the principal catalyst used for this purpose. Temperatures range from 80-130°C (180-270°F) with pressures of 13-20 atmospheres (200-300 psi).

I.B.12. Reforming

Reforming is a process in which a variety of complex and cyclic hydrocarbons are converted to hydrocarbons which produce better gasoline and does so with a much lower use of catalysts.

Platinum and molybdenum are used to produce the following changes:

- Naphthalene dehydrogenation (removal of hydrogen)
- Naphthalene dehydroisomerization (removal of hydrogen and isomerization)
- Paraffin dehydrocyclization (removal of hydrogen and oxygenation of paraffins)
- Paraffin isomerization
- Paraffin hydropacking
- Olefin hydrogenation (addition of hydrogen to unsaturates)
- Hydrodesulfurization (addition of hydrogen and elimination of sulfur)

Catalyst	Process	Changes
Platinum	Naphthalene dehydrogenation	Removal of hydrogen
Platinum	Naphthalene dehydroisomorization	Removal of hydrogen and isomerization

I.B.13. Coking

Coking is a process in which contact times are lengthened in a thermal cracker so that polymerization or condensation products are produced. However, only the most degraded carbonaceous high-boiling parts of the cracking reaction are exposed. Coking takes place at temperatures over 435°C (820°F). The main purpose of coking is the production of coker gas oil which is charged to catalytic or thermal crackers. In addition, coke is heated in kilns at 590-650°C (1100 - 1200°F) to produce artificial graphite.

I.B.14. Asphalt Production

Asphalt is produced by vacuum flashing of hot cracked tar as part of the cracking operation or from the steam distillation of various stages. The quality of asphalt can be improved by air blowing with the use of ferric chloride or phosphorous cutoxide. Heavy topped crude oil or vacuum reduced residue is heated to within 30°C (50°F.) of its flash point and blown with 1-1.6 cu. meters/minute/metric ton (30-50 cu. ft./minute of air/ton of asphalt)over a period from 1.5 to 2.4 hours.

I.B.15. Catalyst Regeneration

Solid catalysts used in cracking are thermally regenerated by air blowing followed by a nam purge with steam jet ejectors. This is carried out either in the catalyst reactor bed or in a separate regeneration unit.

I.B.16. Lube Oil Production

Reduced oxide is taken to a vacuum fractionator where gas oil is removed. The various fractions other than the residual is sent to solvent extraction where various solvents (i.e., phenol, forfural) and used to recover the lube oil fraction. This is then sent to a solvent dewaxing unit where propane or methyl ethyl ketone is used to remove wax. The produce is heated with clay to remove acid values.

I.B.17. Propane Deasphalting

Propane is used to separate asphalt from oils. The propane is used to extract oil from asphalt producing a higher quality product than vacuum distillation. The process is basically an extraction process at temperatures of 70-90°C (160-190°F) and a pressure of 27-41 atmospheres (400 - 600 psi).

I.C. TRENDS

I.C.1. Locational Changes

US refineries are concentrated largely in areas of major crude production (California, Texas, Louisiana, Oklahoma, and Kansas) and in major population areas (Illinois, Indiana, Ohio, Pennsylvania, Texas, and California) (US EPA 1973). Projected geographic growth patterns of new refineries by Petroleum Administration for Defense (PAD) Districts through 1981, shown in Table 3, indicate little change in this locational pattern.

The majority of 1977 growth was in PAD District III, as shown in Figure 4. Most of this growth occurred in Texas and Louisiana. The next largest growth was in PAD District V where California accounted for the largest increase in new and expanded capacity. Alaska, however, had one new and one expanded refinery. Texas and Louisiana continue to lead the growth trends through 1981. Outside those states a new 175,000 bbl/day facility in Portsmouth, Virginia, in 1980 and a 250,000 bbl/day refinery in Eastport, Maine, in 1981 are the largest planned capacity additions. Large new projects not reflected in Table 3 which are in early or uncertain stages of planning include (FEA 1977):

200,000 bbl/day at Baltimore, Maryland
250,000 bbl/day at Sanford, Maine
200,000 bbl/day at Oswego, New York
400,000 bbl/day at Sagbrook, Connecticut

PAD Districts are anachronisms relating to the old Petroleum Administration for Defense which ceased to exist many years ago. The districts are shown geographically in Figure 4. Figure 5 presents the concentrations of petroleum refinery operations by EPA regional office jurisdictions.

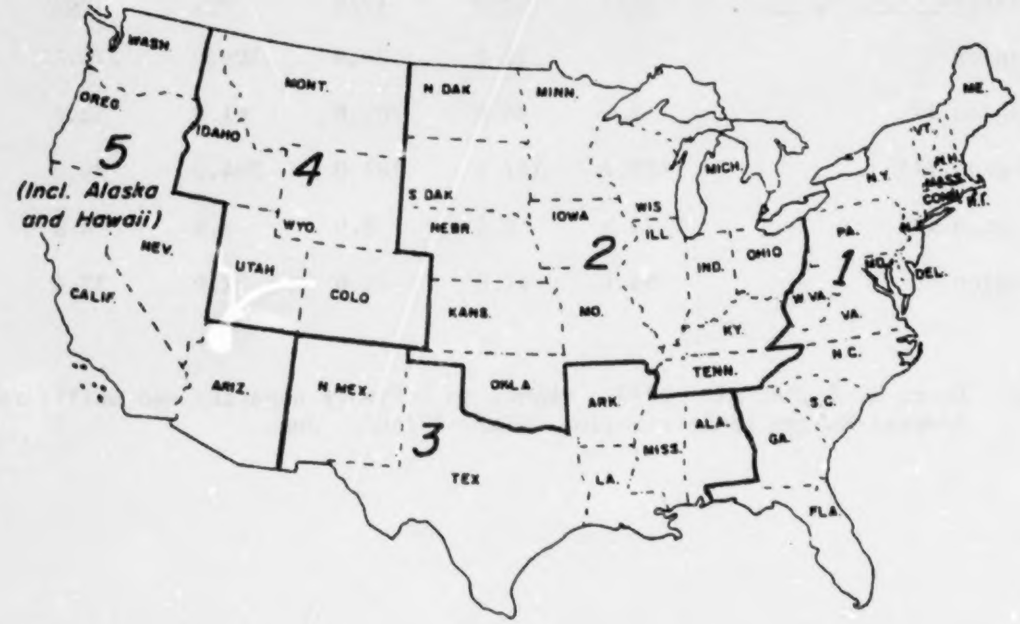
In short, the consenses among industry representatives is that little or no significant change is expected to occur in locational patterns unless substantial quantities of oil are discovered and produced offshore on the East Coast (Interview, Mr. Eugene Peer, Office of Oil and Gas, DOE, 18 April 1978).

Table 3. Projected geographical distribution of new, expanded, or reactivated U.S. refining capacity by PAD District (thousands of bbl/day, crude distillation).

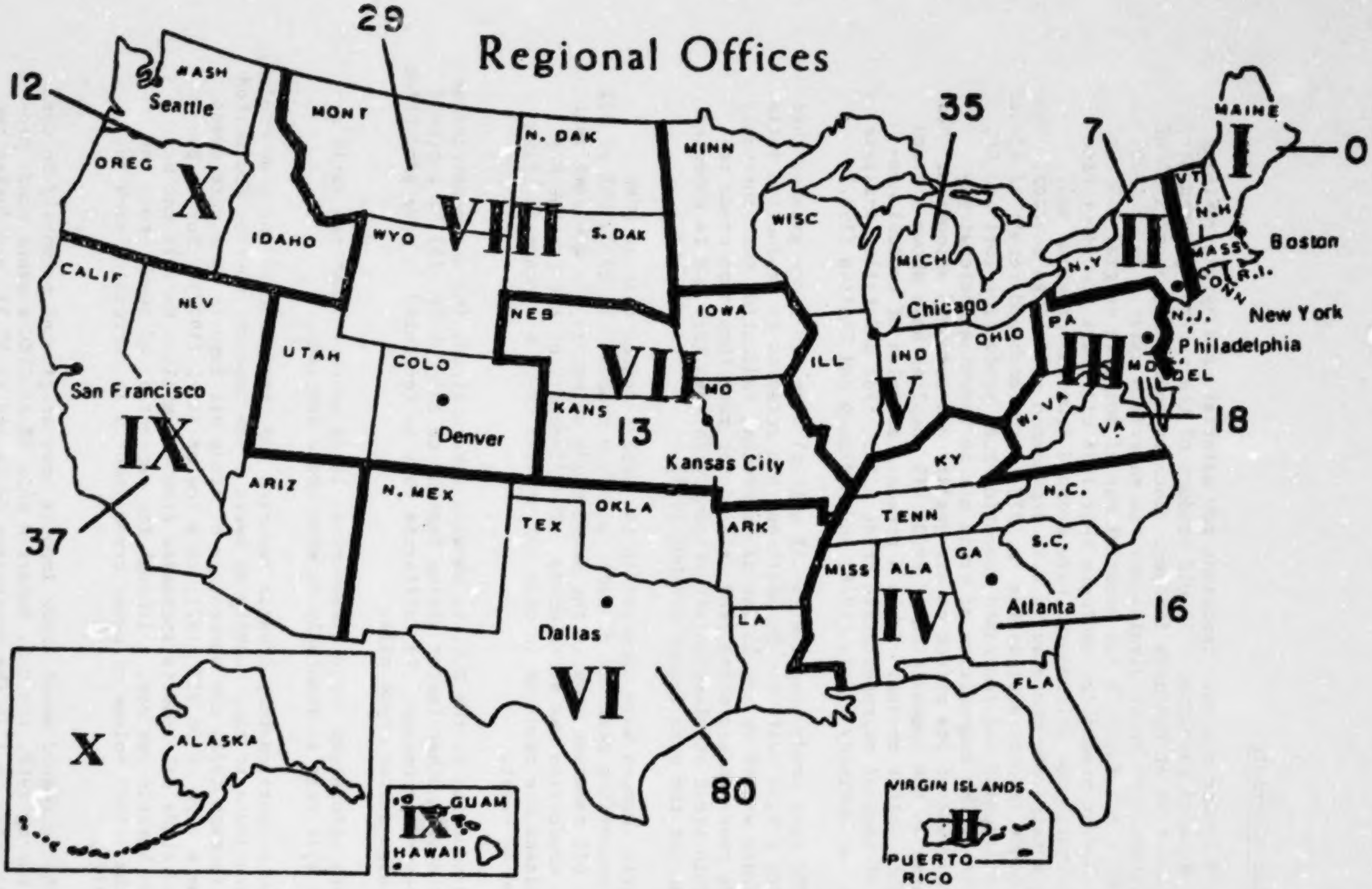
Total New, Expanded, or Reactivated Capacity	1977	1978	1979	1980	1981
PAD Region I	-	12.0	24.0	199.0	274.0
PAD Region II	2.5	36.0	101.0	61.0	52.0
PAD Region III	478.2	117.0	181.0	284.0	84.0
PAD Region IV	24.5	9.4	8.0	8.0	8.0
PAD Region V	84.1	41.0	32.0	32.0	32.0

Source: Peer, E. L., et al. 1977. Trends in refinery capacity and utilization. Federal Energy Administration, FEA/G-77/281. June.

Figure 4. Geographical locations of Petroleum Administration for Defense (PAD) Districts.


WASH
OREG.
IDAHO
MONT.
N DAK
MINN.
ME.
VT.
N.H.
MASS.
CONN.
R.I.
N.Y.
MICH.
5
(Incl. Alaska
and Hawaii)
4
S DAK
NEBR.
WYO.
IOWA
WIS
ILL.
PA.
NEV.
UTAH
COLO
2
IND.
OHIO
1
MD.
DEL.
CALIF.
KANS.
MO.
W VA.
VA.
KY.
N.C.
TENN.
OKLA
ARIZ.
N MEX.
ARK.
S.C.
ALA.
3
MISS.
GA.
TEX
LA.
FLA.

Source: Peer, E. L., et al. 1977. Trends in refinery capacity and utilization. Federal Energy Administration, FEA/G-77/281. June.


Regional Offices
29
12
35
7
0
18
13
16
37
80
I
II
III
IV
V
VI
VII
VIII
IX
X
WASH
Seattle
OREG
IDAHO
MONT
WYO
N. DAK
S. DAK
MINN
WISC
MICH
CALIF
NEV
UTAH
COLO
Denver
NEB
KANS
IOWA
MO
Kansas City
ILL
IND
Chicago
OHIO
PA
N.Y
MAINE
VT
N.H
MASS
Boston
R.I.
CONN
N.J.
New York
Philadelphia
MD
DEL
W. VA
VA
KY
TENN
N.C.
S.C,
GA
Atlanta
ALA
MISS
FLA
ARK
LA
OKLA
TEX
Dallas
ARIZ
N. MEX
San Francisco
ALASKA
GUAM
HAWAII
VIRGIN ISLANDS
PUERTO RICO

Source: U.S. EPA. 1976. Assessment of hazardous waste practices in the petroleum refining industry. Prepared by Jacobs Engineering Company. NTIS PB-259-097. Springfield VA.

Figure 5. Numbers of petroleum refineries within EPA regional jurisdictions (Arabic numbers indicate number of refineries in each region).

I.C.2. Raw Materials

Crude oil is by far the most important raw material used by the refining industry. Natural gasoline, a liquid product of the natural gas industry, furnishes about 5% of refinery intakes. Butanes contribute about 1.5% of refinery intake. No other significant raw materials exist. As of 1976, about 73% of the industry's raw material was of domestic origin; 27% was imported. Recent statistics indicate that 1978 will mark the first time since 1970 that crude oil imports have dropped from the previous year, permitting a temporary decrease in U.S. dependence on foreign sources. The volume of crude imports anticipated in 1978 is the combined result of slower growth in oil demand and increased domestic crude production (Oil and Gas Journal 1978). The composition of crude oil is becoming increasingly important because of its effect on air quality and industry economics. However, changes in the composition of crude oil supplies have shown a trend toward higher sulfur crudes. Table 4 presents examples of typical compositions of several representative crude oils. (For a detailed analysis of crude oils see McKinney et al. (1966) and McKinney and Shelton (1967).

In 1975 OPEC sour crude reserves (> .5% sulfur) were 5.5 times greater than sweet crudes (<.5% sulfur). In addition, the reserves to production ratio of sour crudes was 49 versus 33 for sweet crudes, indicating that currently sweet crude reserves are being used at a higher rate than sour crude reserves. This trend accelerated significantly through 1977 and is expected to continue for the near future (US-DOE 1977).

More dramatic changes have occurred in the United States than in OPEC countries concerning reserves of sweet and sour crudes. In 1964, 64% of all U.S. crude oil reserves were in the sweet crude category. In the same year 66% of the production was sweet crude. The discovery of the Prudhoe Bay field in Alaska has resulted in only 42% of 1975 crude oil reserves being categorized as sweet.

In 1978, production in the U.S. is showing a significant increased percentage of sour crude. Another factor giving impetus to this shift will be improved sulfur recovery processes. In California this is reflected in more production of heavy, high sulfur crude oils.

Short of any unforeseen large discoveries, it is expected that the world's refineries will rely increasingly on sour crude supplies.

Despite the proportionately greater reserves and the production of sour crudes, the U.S. continues to rely heavily on sweet crude imports. During the period from 1969 through 1977, the percentage of crude oil imports that were sweet ranged from a high of 66.95% (1972) to a low of 54.7% (1977). During the same period crude oil imports increased from 2.2 million barrels per day to 6.6 million barrels per day. Although the percentage of sweet crude has dropped, the actual volume of sweet crude imports is increasing each year (US-DOE 1977).

Recently the increased sweet crude imports have originated primarily in OPEC sources. During 1969, the U.S. imported only 5% of OPEC's sweet crude production; however, in 1976 the percentage increased to 37.57, and during the

Table 4. Examples of typical compositions of representative crude oils.

	Gravity °API	Sulfur Wt.%	Viscosity Saybolt, at 100°F, seconds	Carbon Residuum Wt.%	Gasoline Anonaphtha		Kerosine Distillation	
					Vol. %	Gravity °API	Vol. %	Gravity °API
California								
Brea Olinoa	24.0	0.75	135	14.2	17.4	51.3	-	-
Elk Hills	22.8	0.68	135	4.6	11.1	49.9	-	-
Torrance	23.8	1.84	160	13.2	17.9	52.5	-	-
Louisiana								
Black Bay	30.0	0.27	57	6.3	15.2	54.2	5.5	42.1
Grand Isle	36.4	0.18	40	3.7	25.8	54.7	15.0	11.7
West Delta	27.0	0.33	92	5.7	9.5	50.9	4.7	40.0
Oklahoma								
Bradley	35.0	0.22	56	6.7	24.3	57.4	15.6	43.0
Golden Trend	42.1	0.11	39	2.7	34.6	62.9	17.1	42.8
Sho-Ven-Tu	29.1	1.36	87	10.1	21.2	59.5	4.3	42.8
Texas								
Conroe	37.0	0.10	36	4.9	32.8	48.8	-	-
East Texas	37.4	0.25	42	6.1	33.9	58.2	5.0	42.8
Walnut Bend	46.0	0.23	38	3.3	38.3	64.5	16.5	43.4
Libya	39.2	0.33	40	7.6	36.6	59.9	12.2	43.4
Indonesia	36.8	0.10	35	3.8	37.1	52.5	-	-
Iran	34.6	1.43	46	9.1	28.8	60.8	10.2	43.2
Iraq	36.6	1.93	42	14.6	35.5	63.7	9.8	44.5
Saudi Arabia	33.6	1.66	49	11.3	27.8	62.3	9.9	44.7
Venezuela	14.7	2.62	310	9.6	5.7	45.6	-	-

Source: McKinney, et al. 1966. Analyses of crude oils from 546 important oil fields in the United States. Prepared for US-DOI. Bureau of Mines Report of Investigations 6819. Available US-GPO, Washington, D.C.

first quarter of 1977 it increased to 42%. By contrast, during the same 4-month period in 1977, the U.S. imported only 12.4% of OPEC's sour crude production (US-DOE 1977).

I.C.3. Processes

As in most industries, trends in process change are likely to be closely tied to or motivated by pollution control requirements. This is true because few industrial processes can be altered significantly without introducing some effect on waste generation. If a process change improves efficiency, is cost-effective, and does not adversely effect waste generation, it normally has high use potential. In contrast there must be significant tradeoffs in process change efficiency and economy to tolerate generation of additional or more complex wastes, since the treatment or control of these wastes would tend to offset the benefits. Commonly, process change is effected because its improved efficiency and economy lie not solely in its own performance per se, but in reduced waste generation. Therefore trends in internal pollution control are addressed concomitantly with trends in process change. Trends in external pollution treatment, control, and disposal methods are discussed in Section I.C.4.

To assist in the projection of process trends a historical perspective of degrees of application or use of the various processes and subprocesses is meaningful. A comprehensive survey of every process in every refinery would be beyond the scope of this study; therefore, based on a review of the literature this analysis was done only for the major processes and subprocess alternatives. The percent use of these basic processes and major subprocesses by U.S. refineries is presented in Table 5.

The discussions of current and future process trends which follow are largely based on recent literature (US-EPA 1973a-d; US-EPA 1976a-d; FEA 1977; US-DOE 1977) and on conversations with key individuals knowledgeable of changes in the petroleum refining industry.

I.C.3.a. Storage and Transportation

Crude oil and product storage.

Many refineries already had installed equipment to minimize the release of hydrocarbons from crude and product storage areas to the atmosphere before the storage regulations discussed in Section I.D.2 were promulgated. Doubtless some motivation was provided by Rule 66 of the Los Angeles Air Pollution Control District, which regulates photochemical oxidants and other state and local regulations patterned after Rule 66. Refineries also were motivated by the economics of product loss versus vapor recovery.

Storage regulations now require the use of alternative technologies-floating-roof covers, pressurized tanks, and/or connections to vapor recovery systems --so the trend in this direction should accelerate. Floating roof tanks permit the stored products to expand and contract without exhausting vapors to the external environment. Although floating-roof covers can add to the wastewater flow from storage tanks, strict refinery specifications on the characteristics of crude oil supplies will minimize wastewater from modern crude storage facilities. A factor which will tend to reduce quantities of wastewater from

Table 5. Estimated percentage of petroleum refiniries using various manufacturing processes.

Process	Percentage Use by Year					Technological Status[1]
	1950	1963	1967	1972	1977	
Crude oil desalting		100%	100%	100%	100%	
-Chemical desalting		5	2	0	0	O
-electrostatic desalting		95	97	100	100	T,N
Crude distillation	100%	100	100	100	100	
-Atmospheric fractionator	100	100	100	100	100	O,T,N
-Vacuum fractionator		60	64	70	75	O,T,N
-Vacuum flasher						
Thermal cracking	59	48	45	40	35	
-Thermal cracking		28	18	8	2	O
-Delayed coking		12	14	16	19	T,N
-Visbreaking		13	16	18	22	T,N
-Fluid coking		2	2	4	6	T,N
Catalytic cracking	25	51	56	60	65	
-Fluid catalytic cracking		39	45	50	60	T,N
-Thermofor catalytic cracking		13	12	10	6	O
-Houdriflow		3	3	2	0	O
Hydrocracking	0	2	8	25	34	
-Isomax			4	11	15	N
-Unicracking			2	8	12	N
-H-G hydrocracking		0.3	0.8	3	3	N
-H-oil			0.4	1	1	N
Reforming		62	67	74	79	
-Platforming		37	40	44	47	O,T,N
-Catalytic reforming-Englehard		5	9	11	12	O,T
-Powerforming		1	2	3	3	T,N
-Ultraforming		6	6	7	8	T,N
Polymerization	25	42	33	26	7	
-Bulk acid polymerization						T,N
-Solid phosphoric acid condensation						T O
-Sulfuric acid polymerization						
-Thermal polymerization		1	0.4			O
Alkylation	10	38	47	54	62	
-Sulfuric acid alkylation		22	26	32	38	T,N
-HF alkylation		16	21	22	25	O,T,N
-DIP alkylation						N
-Thermal alkylation						O

Table 5. Estimated percentage of petroleum refineries using various manufacturing processes (continued).

	Percentage Use by Year				Technological Status[1]
	1963	1967	1972	1977	
Isomerization	5%	7%	10%	15%	
-Isomerate	1	1.5	3	6	N
-Liquid-Phase Isomerization	2	3	4	5	N
-Butamer	1	1	2	2	N
-Penex	0.7	1	1	2	N
Solvent Refining	25	29	30	32	
-Furfural Refining	14	15	16	16	O,T,N
-Duo-Sol	2	3	3	3	T,N
-Phenol Extraction	10	10	11	11	O,T,N
-Udex	3	5	8	8	T,N
Dewaxing	11	11	11	11	
-Solvent Dewaxing (MEK)	8	8	9	9	O,T,N
-Propane Dewaxing	2	2	2	2	O,T
-Pressing and Sweating	1	1	0	0	O
Hydrotreating	47	56	70	80	
-Unifining	22	23	30	35	T,N
-Hydrofining	3	3	5	8	T,N
-Trickle Hydrodesulfurization	0.3	2	4	5	T,N
-Ultrafining	3	5	8	10	T,N
Deasphalting	20	23	25	27	
-Propane Deasphalting and Franctionation	15	18	20	21	O,T,N
-Solvent Decarbonizing	4	5	5	6	T,N
Drying and Sweetening	80	80	80	80	
-Copper Sweetening					O,T
-Doctor Sweetening					O
-Merox					N
-Girbotal					O,T,N
Wax Finishing	11	11	11	11	
-Wax Fractionation	10	9	6	5	O,T
-Wax Manufacturing, MIBX	1	1	1	1	O,T,
-Hydrotreating		1	4	5	N
Grease Manufacture	12	12	10	10	O,T,N
Lube Oil Finishing	19	19	20	20	
-Perculation Filtration	11	7	5	2	O,T
-Continuous Contract Filtration	6	7	7	7	O,T
-Hydrotreating	2	5	8	11	N

Table 5. Estimated percentage of petroleum refineries using various manufacturing processes (concluded).

	Percentage Use by Year				Technological Status[1]
	1963	1967	1972	1977	
Hydrogen Manufacture	2	8	25	34	
-Hydrogen Partial Oxidation	1	3	10	12	N
-Hydrogen, Steam Reforming	1	5	15	22	
Total No. of Refineries	293	261	236	211	

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[1] O = Older - Refineries which use relatively inefficient and/or obsolescent processes and subprocesses

T = Typical - Refineries which use those processes and subprocesses that are most common today

N = Newer - Refineries which use all or most of the advanced processes and subprocesses available

Source: US-DOI. 1967. The cost of clean water. Volume III Industrial Waste Profile No. 5: Petroleum Refining. Prepared for FWPCA. Available from US-GPO, Washington, DC.

finished product storage is the trend toward increased use of dehydration or drying processes ahead of produce finishing (US-EPA 1973a).

- Crude oil and product transportation

The trend in tanker use for shipping intermediate and final products is to larger and larger vessels which arrive at the refinery in ballast and must discharge wastewaters from up to 30% of their capacity. If the discharge is sent directly to the wastewater treatment system, a shock load could result. Thus, the use of larger ballast water storage tanks or holding ponds will be necessary to control the flow into the treatment system. The discharge of ballast wastewater directly into ocean or estuarine areas without treatment is now illegal and is expected to be eliminated completely (US-EPA 1973a).

I.C.3.b. Crude Oil Desalting

The current trend is toward increased use of electrostatic desalting and less use of chemical processes to remove inorganic salts and suspended solids from crude oil prior to fractionation. In the future, chemical methods may be used only as a supplement where the crude has a high salt content. A two-stage electrical desalting process is expected to be used as "dirtier" crude feedstocks are processed. The growth in capacity of desalting units will be proportionate to the growth in crude oil capacity.

I.C.3.c. Crude Oil Fractionation

The trend is toward large and more complex combinations of atmospheric and vacuum towers with more individual sidestream products.

I.C.3.d. Cracking Operations

- Thermal cracking

Regular thermal cracking, which was an important process before the development of catalytic cracking, is being phased out. Visbreaking and coking units are still installed, but at a slower rate than before, because of product sulfur restrictions. Whereas the current trends are toward dirtier crudes with higher sulfur content, hydrocracking, and propane deasphalting (which break down high molecular weight compounds and remove sulfur from the compounds to form clean low molecular weight materials) are expected to receive more attention to recover saleable products with low sulfur content from the residuum.

- Catalytic cracking

Recycle rates have been declining since 1968 and the trend is expected to continue because of the development of higher activity catalysts (molecular sieve catalysts, instead of high surface area silica-alumina catalysts). Large fluidized catalytic cracking processes, in which the finely-powered catalyst is handled as a fluid, largely have replaced the fixed-bed and moving-bed processes, that use a beaded or pelleted catalyst.

- Hydrocracking

This process continues to be an efficient, low to moderate temperature, catalytic method for conversion of refractory middle boiling or heavy feedstock into high-octane gasoline, reformer charger stock, jet fuel and/or high grade fuel oil. Hydrocracking still possesses considerable flexibility (relative to catalytic cracking) in adjusting operations to meet changing product demands. At one time, hydrocracking was a rapidly growing refinery process; however, its growth rate is now stable (about 1.5 percent/year) because of high investment costs and the large quantities of expensive hydrogen that are required for operation. Primary catalysts which currently are used in hydrocracking include tungsten sulfide-silica alumina, and nickel-silica alumina.

I.C.3.e. Hydrocarbon Rebuilding

- Polymerization

This process currently is used by only a small number of refineries because the product octane is not sufficiently higher than that of the basic gasoline blending stocks to significantly upgrade the overall motor fuel pool. Also alkylation yields per unit of olefin feed are much better than polymerization yields. Consequently, the current polymerization downtrend is expected to continue. The primary catalysts used include copper pyrophosphate and phosphoric acid.

- Alkylation

Alkylation (used to produce a high octane product) process capacity is expected to increase in response to the demand for high octane low lead gasoline.

I.C.3.f. Hydrocarbon Rearrangements

- Isomerization

Reforming capacity in the U.S. currently is expanding at about the same rate as total crude capacity. This growth rate should continue to increase as the demand for motor fuel grows.

- Reforming

No significant changes are expected except for a change to multireactive, fixed bed, catalytic processes in place of thermal units.

I.C.3.g. Solvent Refining

Generally solvent extraction capacities are expected to increase slowly as quality requirements for all refinery products become more stringent, as the demand for the lube oils grows, and as the petrochemical industry continues to require increased quantities of aromatics.

I.C.3.h. Hydrotreating

Hydrotreating was first used primarily on lighter feedstocks, however, with more operating experience and improved catalysts, hydrotreating has been applied to heavier fractions such as lube oils and waxes. It has been one of the most rapidly growing refinery processes. It should continue to increase at a greater rate than crude capacity because the process can be applied to most sour feedstocks, it is flexible, and it also eliminates contaminants of concern to the refining industry from an operating standpoint and to the general public from an aesthetic standpoint. Among the catalysts most commonly used in hydrotreating are alumina, cobalt molybdate, nickel sulfide platinum, silica alumina, and tungsten nickel sulfide.

I.C.3.i. Grease Manufacturing

Because of developments in sealed grease fittings and longer lasting greases, grease production generally is expected to decline.

I.C.3.j. Product Finishing

- Drying and sweetening

Air quality regulatory agencies are expected to increase their efforts to control emissions of sulfur. Therefore restrictions which govern sulfur contents in fuels are expected to become stricter. This will generate a trend toward replacement of the sweetening processes by hydrotreating (desulfurization), because hydrotreating removes most sulfur compounds and not just hydrogen sulfide,mercaptans, and elemental sulfur. Nevertheless, efficacy and economics will ensure the use of sweetening processes for certain feedstocks, excepting those processes which produce high waste loads.

- Lube oil finishing

The two methods most widely used by industry are: (1) continuous contact filtration in which an oil-clay slurry is heated and the oil removed by vacuum filtration; and (2) percolation filtration, in which the oil is filtered through clay beds. Percolation also involves naphtha washing and kiln-burning of spent clay to remove carbon deposits and other impurities. It is expected that acid and clay treatment of lube oils eventually will be replaced by hydrotreating techniques with elimination of important wastewater streams. Acid treatment has been significantly reduced.

- Blending and packaging

It is expected that there will be increased use of automated proportioning facilities for the blending of products with a trend toward contracting out of packaging of lower-volume products that are less suitable to highly-automated operation.

I.C.3.k. Auxiliary Activities

- Hydrogen manufacture

Past and present growth in hydrotreating and hydrocracking processes will result in a continued demand by new refineries for hydrogen, to a level beyond that obtained as a byproduct of reforming and other refinery processes. The demand for hydrogen as a feedstock for the manufacture of ammonia and methanol also is expected to continue. Currently the most widely used subprocess is steam reforming, in which desulfurized refinery gases are converted to hydrogen, carbon monoxide, and carbon dioxide in a catalytic reaction; this generally requires the use of an additional shift converter which converts carbon monoxide to carbon dioxide.

I.C.4. Pollution Control

Because of crude supply limitations, new refinery capacity will be designed to process higher sulfur crudes which means a corresponding increase in desulfurization capacity. The increased use of sour (higher sulfur) crude feedstock from outside the U.S. will require changes in processing equipment, in-plant wastewater control, and treatment operations. There are refineries that consume sweet crude stock, but do not employ strippers to remove minimal amounts of ammonia and hydrogen sulfide from wastewaters. Increases in sour crude processing within these refineries will require sour water strippers to be used prior to discharge of the wastewaters to biological wastewater treatment facilities. Generally, pollution control techniques with a higher level of removal will continue to replace older techniques. These techniques include use of incinerators to destroy trace organic discharges, use of reactor exhausts as furnace air to reduce gaseous organic discharges, improved treatment of sour heavy bottoms, more effective control of emissions of sour gases, and increased emphasis on wastewater reuse/recirculation techniques such as:

- The use of catlytic cracker accumulator wastewaters rich in H_2S (sour waters) for makeup to crude desalters
- The use of blowdown condensate from high-pressure boilers for makeup to low-pressure boilers
- The reuse of waters that have been treated for closed cooling systems, fire mains, and everyday washing operations
- Stormwater use for routine water applications
- Blowdown waters from cooling towers for use as water seals on high-temperature pumps
- The recirculation of steam condensate
- The recycling of cooling waters

Good maintenance practices can effectively reduce waste streams. More emphasis is being place on:

- The recovery of oil spills and hydrocarbons with vacuum trucks to reduce emissions and water effluents
- Reduction of leaks and accidents through preventive maintenance
- The separation of hazardous wastes, concentrated wastes, and other process wastes from general effluents for more effective treatment
- The diking of process unit areas to control and treat spills, oily stormwater runoff, or periodic washes
- The reduction of shock pollutant loads on treatment facilities through the periodic flushing of process sewers to prevent contaminant build-up
- Specialized programs for handling hazardous wastes, sludges, washwaters, and other effluents
- Systems to minimize wastes from monitoring stations
- Personnel awareness that the waste treatment is initiated at the process unit

Process modifications often reduce waste streams significantly while returning a recovery value. Technology changes that reduce pollution may not be as cost effective during process cycles, but may prove to be highly beneficial when waste treatment costs have been reduced. Depending on the feasibility and suitability of a particular project, such process technology changes are expected to include:

- Catalyst switching to one of longer life and greater activity thereby reducing regeneration rates
- Reduction in cooling water usage through the implementation of air-fin coolers
- Reduction in spent caustic and sulfides loadings through use of hydrocracking and hydrotreating processes
- Inclusion of process control instrumentation to employ emergency shut-downs or control upset conditions
- Minimization of filter solids, water washes, and spent caustics and acids through the optimization of drying, sweetening, and finishing processes
- Higher removal of organics and residual solids

The removal of heavy metals from catalyst systems and specific toxic organics also is being stressed. Treatment systems to remove heavy metals and organics (i.e., precipitation, ion exchange, phenol removal by solvent extraction), settling and filtration techniques to remove suspended solids and physical systems to remove specific organics are now becoming common practice.

Table 6 presents historical trends (1950 to 1977) in the use of various waste water treatment methods by oil refineries.

I.C.5. Environmental Impact

Federal and State regulations for water and air pollutants (Clean Water and Air Act Amendments of 1977) and solid waste generation and disposal (Toxic Substances Control Act; Resource Conservation and Recovery Act) have resulted in improvements in the technological design and efficiency of pollution control methods. More attention is being given to the siting of major new industrial facilities in recognition of the increased emphasis on State, regional, and local land use planning. Also, owing to the ratification of the National Environmental Policy Act and other legislation, government decision making is more exposed to public scrutiny and to a more objective, complete environmental review process. Thus, refineries which have become operational since the early 1970's generally can be expected to have less waste stream-related impacts than those built a decade or two ago. Small refineries (<10,000 B/CD) are expected to increase because of incentives provided in Federal entitlement programs, as well as due to a general increase in industrial activity; therefore, more consideration will be given to the assessment of cumulative and secondary impacts from siting new refinery facilities.

I.D. MARKETS AND DEMANDS

I.D.1. Refinery Capacity

During the period from 1 January 1960 to 1 January 1977, U.S. refinery

Table 6. Estimated percentage of petroleum refineries using various wastewater treatment processes.

Processes and Subprocess	1950	1963	1967	1972[b]	1977[b]
API Separators	40%	50%	60%	70%	80%
Earthen Basin Separators	60	50	40	30	20
Evaporation	0-1	0-1	1	1-2	2-5
Air Flotation	0-1	10	15	18	20
Neutralization (total wastewater)	0-1	0-1	0-1	0-1	0-1
Chemical Coagulation and Precipitation	1-5	1-5	5-10	10-15	10-15
Activated Sludge	0	5	10	40	55
Aerated Lagoons	0	5	10	25	30
Trickling Filters	1-2	7	10	10	10
Oxidation Ponds	10	25	25	25	20
Activated Carbon	0	0.5	0.5	3	5
Ozonation	0	1	1	3	5
Ballast Water Treatment (Physical)	9	9	8	5	5
Ballast Water Treatment (Chemical)	1	1	2	5	5
Slop Oil-Vacuum Filtration	0	5	7	12	15
Slop Oil-Centrifugation	0	2	3	10	15
Slop Oil-Separation	100	93	90	80	70
Sour Water-Stream Stripping					
Flue Gas Strippers	60	70	85	90	90
Natural Gas					
Sour Water-Air Oxidation	0	3	3-5	7	10
Sour Water-Vaporization	1	1-2	1	0	0
Sour Water-Incineration[a]	35-40	40	50	30	20
Neutralization of Spent Caustics					
Flue gas	20	30	35	20	20
Spent acid (including springing and stripping)	15	25	30	25	20
Oxidation	0	3	5	5	5
Incineration[a]	25	40	50	20	15

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[a] Incineration includes flaring, boiler furnaces, and separate incinerators used only in conjunction with stripping and vaporization.

[b] Estimated

Source: US-DOI. 1967. The cost of clean water, Volume III, Industrial Waste Profiles no. 5 - petroleum refinering. FWPCA, Washington, DC.

operation capacity increased about 7.0 million barrels per calendar day (9.5 million B/CD to 16.5 million B/CD). This increase represents an average compounded growth rate of about 3.5 percent per year; however, this growth has not been equal in all PAD districts. The highest growth during this period occurred in PAD district III, whereas the lowest occurred in PAD district I (see Figure 4 for the geographical distribution of PAD districts) (FEA 1977a, 1977b). Future trends show total operable capacity to rise to:

- 17.0 million B/CD in 1978
- 17.3 million B/CD in 1979
- 17.6 million B/CD in 1980
- 18.2 million B/CD in 1981
- 18.6 million B/CD in 1982

and actual crude runs through 1981 are estimated (by Bureau of Mines) to be about 90 percent of the above total operable capacities, or 15.4 million B/CD in 1978; 15.5 million B/CD in 1979; 15.8 million B/CD in 1980; and 16.4 millio B/CD in 1981.

Discrepencies do exist, however, among authroities for crude capacity projections. For example, Oil and Gas Journal figures (Lange 1978) for crude runs during 1977 and 1978 are lower than those determined by the Bureau of Mines and the Office of Oil and Gas (FEA 1977a) as indicated below:

	1977 (million B/CD)	1978 (million B/CD)
O & G Journal	14.6	14.9
BM/OOG	14.9	15.3

Under the President's proposed National Energy Plan (NEP), the petroleum product demand is expected to rise only slightly, but U.S. refinery output is expected to increase at a greater rate owing to a decline in product imports forced by a sharp decrease in residual fuel oil demand. Nevertheless, the required increase in refinery output is less than that capacity currently planned. Capacity additions are expected to total 2.1 million barrels per day between 1977 and 1982. Even if some of the projects scheduled to come on stream between 1977 and 1982 fail to materialize, the addition of as little as 1.0 million barrels per day is expected to meet future demand (1985) at reasonable upper limits of refinery utilization. Because there probably will be some growth in petroleum product demand between 1985 and 1990, some added capacity beyond the 1.0 million barrels per day would be needed during that period.

One very significant impact of the President's NEP is the substantial reduction in residual fuel oil demand which drops from 3.5 million barrels per day in the base case to 2.0 million barrels per day under the program. Whereas U.S. refineries in the 50 States already are capable of producing 2.0 million barrels per day of residual fuel oil, it would appear that all export refineries in the Bahamas/Caribbean refineries probably would continue operations while U.S. refineries would tend to minimize residual fuel oil production to the extent possible, while still maintaining operations to produce other necessary products.

The base case, for petroleum product demand which represents anticipated 1985 and 1990 demand without the President's program was also developed. The requirement for new refinery capacity would be 3.6 million barrels per day by 1985 for the base case as compared with 1.9 million barrels per day of planned "firm" projects (FEA 1977b).

I.D.2. Incentives

Currently the primary incentive to refine domestically (as opposed to abroad) is the Federal entitlements program. A secondary incentive is the import fee system which has been active since April 1973. Under the entitlements program, because of price controls, the average refiner pays less for his crude oil than other countries pay for foreign crude oil. This large advantage endangered U.S.-owned refinery operations in the Bahamas and Caribbean with the result that partial entitlements were given to residual fuel oil importers.

With the application of the crude equalization tax under the NEP, the advantage offered by the entitlements system will disappear, and leave import fees as the last significant element to encourage domestic refining.

Other factors for consideration include increased investment tax credits and accelerated depreciation on new facilities or modification to existing facilities. The NEP also will affect refinery operations through the user's tax which is to be paid on liquid fuels burned in the refinery. Current technology does not permit the burning of coal in process furnaces. If the cost of the tax can be passed through or exceptions granted, it will not affect refineries. According to the NEP Macro Economic Effects, one-third of the crude oil equalization tax will have to be absorbed by refineries which may nullify the protection of the product import fee.

I.D.3. Changes in Refinery Configuration

Although the general trend has been toward fewer, but larger refineries this trend appears to be reversing. The capacities of the 285 refineries operating as of 1 January 1978, ranged from 32 m^3/day (200 B/CD) to 69,000 m^3/day (434,000 B/CD). Refineries with unit capacities over 15,900 m^3/day (100,000 (B/CD) represented only 11.5% of total refineries in 1967, but accounted for 48% of the refining capacity. By 1972, 16.6% of all refineries exceeded this size and represented 58% of total capacity. However, more recent information indicates that most new refinery construction utilizing fluid catalytic cracking units will range from 25,000 to 50,000 B/CD (USEPA 1976b).

Although larger refineries are able to take advantage of continuous processing units, the number of small refineries (under 10,000 B/CD), both new and reactivated, is increasing. In part, this is because of the small refiner bias in the Federal entitlements program which provides special allocations of petroleum feedstocks to small refineries at a substantial price advantage (FEA 1977b). In point of fact, the smaller the refinery, the greater dollar per barrel advantage. For example, a refinery with 80,000 B/CD capacity receives only one-tenth of the benefits of a 10,000 B/CD facility (Peer and Marsik 1977).

Most of the small refineries being built or planned are of simple design that often consists only of crude distillation towers and storage tanks; therefore, they are less able to respond to changing market demands or to produce more sophisticated products (FEA 1977a).

In contrast, the larger refineries have instituted improvements in technology which have resulted in more sophisticated processing techniques such as fluid-bed catalytic cracking instead of static-bed catalytic cracking, catalytic reforming, and advanced hydrotreating.

Trends in the construction of larger petroleum refineries will be dictated primarily by market demand. This effect was evidenced by the considerable buildup during the 1960's in processes which provided higher octane gasoline. Recently, although there has been a significant reduction in the octane numbers required, the necessity to achieve specific octanes without the addition of lead again has modified petroleum processing. Moreover, the market for low sulfur fuel oil has generated the construction of desulfurization facilities.

The rate of refinery expansion or construction will be influenced by the relative contribution of oil-derived products to the total energy demand. The share supplied by oil is projected to drop from 46% in 1975 to 42% in 1990 (Denman 1978).

Other factors that are expected to influence refinery configurations include:

- Uncertainty of government regulatory requirements
- Threat of legislation to force divestiture by refineries of production and marketing
- Cost and composition of crude oils
- Inflation rates
- Construction costs, pollution control regulations, and equipment costs
- Environmental restrictions and opposition

The above summary represents an overview. For the reviewer who seeks more detailed analyses of this subject see: FEA 1977a; FEA 1977b; US-DOE 1977.

I.E. SIGNIFICANT ENVIRONMENTAL PROBLEMS

I.E.1. Location

Petroleum refinery operations generally are large installations which can occupy considerable acreage. Naturally the areal extent varies with the capacity of the refinery and the extent of ancillary support facilities planned. Most refinery facilities are located either in rural areas or on the periphery of an urban center in the oil producing regions. Because the siting of new source petroleum refineries can involve a significant change in land use, particularly in rural areas, direct and indirect social and ecological impacts may occur. Direct impacts are primarily a function of the type and size of the facility proposed, the composition of the crude oil to be refined, and characteristics of the site (e.g., wetlands versus upland). The extent and significance of secondary or indirect impacts such as induced growth, infrastructure changes, and demographic changes depends largely on the local economy, existing infrastructure, numbers and characteristics of construction workers (e.g., local or nonlocal, size of worker's family) and other related factors. Long term secondary impacts are seldom significant unless the refinery, because of its size, processing methods, and location, employs a sufficient number of workers to result in spin-off developments (commercial, industrial, and residential). A discussion of secondary impact assessment is contained in the existing EPA document, Environmental Impact Assessment Guidelines for Selected New Source Industries, pages III-11-12.

I.E.2. Raw Materials

Serious environmental problems associated with raw materials arise from the production, transport, handling and storage of the crude oil. However a discussion of impacts associated with exploration, development and production activities are not discussed in this report.

Spills, leaks and tank cleaning operations can produce discharges of crude oil into waterways and estuarine waters. Polynuclear aromatic compounds, heavy metals, and nitrogen and sulfur containing organics can pose a serious threat to human life and the ecology.

I.E.3. Process Wastes

Process operations produce a number of liquid wastes which can pose environmental problems. Among the types of effluents which are characteristic of process wastes are the following:

- Free oil
- Emulsified oil
- Condensate waters
- Acid wastes
- Waste caustics
- Alkaline waters
- Special chemicals
- Waste gases
- Sludges and other solids
- Clean cooling water
- Sanitary wastes

Free oil originates from numerous sources such as individual sampling taps, pump gland leaks, valve and pipeline leaks, losses and spills at times of unit shutdown and equipment repair, accidental spills and overflows, tank bottom drawoff, and other miscellaneous sources. Some of the oil becomes emulsified which poses another problem to the engineer.

Condensate waters originate from distillate separators, running tanks and barometric condensers. These waters can contain a variety of chemicals such as sulfur-containing inorganics, acids, alkalis, suspended solids and condensed organics.

Acid wastes arise from the catalytic use of various acids and from the acid treatment of gasoline, white oils, lubricating oils and waxes. They occur as rinse waters, scrubber discharges, spent catalyst sludges, condensate, and miscellaneous discharges resulting from sampling procedures, leaks, spills, and shutdowns. Waste caustics arise from caustic washing and these waste streams include various condensed sulfur compounds and condensed organics.

Alkaline waters arise from washings. Special solvents are used in refining and leaks and spills may burden waste streams.

The bulk of the wastewaters from petroleum refineries is cooling water. This water can become contaminated by oil leaks. They also may contain chromates and other chemicals used in cooling towers. These can pose a serious environmental problem.

Sanitary wastes can be easily treated, either separately or in conjunction with other wastewaters.

Waste gases from petroleum refining are stack gases from furnances and reactors. The particular pollutants of concern are particulates, various sulfur compounds (hydrogen sulfide, condensed sulfur compounts, sulfur dioxide) and various organic products and constituents of crude oil. Leaks and equipment shutdowns constitute a major source of hydrocarbons.

A wide variety of solid wastes are generated in a refinery. These include water and wastewater sludges, waste materials from catalyst reactors and filtration. Slopes from reactors and storage tanks are also a significant source. These sludges may contain organics, sulfur compounds and heavy metals.

I.E.4. Pollution Control

Pollution control measures on waste streams can effectively reduce adverse impacts that result when control is absent; however, the same control measures can create other kinds of impacts. The equipment used to control various waste streams in oil refining facilities also can generate solid and liquid residual wastes which must be treated and disposed of properly. For example, pollution control processes to remove acid components in the gas stream (H_2S) may leave sulfur-based compounds in the exhaust gases. Waste treatment measures for aqueous streams likewise may not be adequate to treat all of the complex organic compounds which are discharged from a petroleum refinery. Therefore, all proposed pollution abatement devices should be well-designed, well-operated, and properly maintained to minimize other pollutant impacts which may result from unnecessary residual waste products.

I.F. REGULATIONS

Federal water pollution regulations are covered primarily by the Standards of Performance for New Sources (SPNS) for the petroleum refining point source category, in Section 40 CFR 419. Control is through the NPDES permit process. Administration and enforcement rest either with USEPA or with those States with approved NPDES permit programs.

Air pollution control standards are enumerated by Federal New Source Performance Standards (NSPS) as described in 40 CFR Parts 50 and 60 and by State and local air pollution regulations. Usually control is through the State regulatory function of licensing the construction of the oil refinery.

Other applicable pollution control regulations include the Federal Resource Conservation and Recovery Act of 1976 and the various state regulations regarding disposal of solid wastes.

I.F.1. Water Pollution Standards of Performance

The effluents of new petroleum refineries or of major alternatives to existing refineries are subject to standards of performance for new sources (SPNS) and pretreatment standards for new sources established under Public Law 92-500, the Federal Water Pollution Control Act, as amended. These standards have been subjected to court challenge, but currently are in effect. The regulations govern conventional pollutants, as they are termed in Section 304(a)(4) of the Clean Water Act of 1977 (P.L. 95-217), and others as follows:

- BOD_5
- TSS
- COD
- Oil and grease
- Phenolic compounds
- Ammonia as N
- Sulfide
- Total chromium
- Hexavalent chromium
- pH

Additional SPNS and pretreatment standards for toxic pollutants applicable to the subcategories of this industry also are being developed. These are required for a specific list of substances by the June 8, 1976 Consent Decree resulting from the recent litigation, Natural Resources Defense Council, Inc., et al. v. Russell E. Train (Civil Action No. 2153-73 U.S. District Court for the District of Columbia) and from the Clean Water Act of 1977. The list appended to the Decree and referenced in the Act, includes a number of exotic organics and heavy metals of concern to refiners. The toxic SPNS and pretreatment standards will be effective immediately upon promulgation.

EPA may revise the list from time to time, adding substances to it and removing others. Thus, after determining the toxic effluents already subject to standards, new source NPDES applicants should obtain the latest version of the list in order to identify other types of effluents which will become the subject of toxic SPNS and pretreatment standards.

The subcategories are further broken down by the use of two factors based on size of plant and process configuration. The product of these two factors is a number by which a specified base SPNS value for each waste parameter for each of the five subcategories is multiplied to obtain a value for a specified plant. Plant size is broken down into seven ranges, giving seven size factors The process factor is broken down into 22 increments, each of which produces a different process factor. An example of the application of the factors was promulgated (40 CFR, Part 419, Subpart D) and is shown in Table 7 for a refinery in the lube subcategory. The SPNS for the five subcategories topping, cracking, petrochemical, lube, and integrated are shown in Table 8.

From review of effluent limitations that reflect the best available treatment economically achievable (BATEA), which were remanded by the courts, EPS is expected to eliminate the size factor and simplify the regulations. Similar action on the NSPS also can be expected.

The pretreatment standards for new source petroleum refineries are nearly identical to the SPNS for each subcategory as presented in Table 8 provided that:

- The SPNS value will be reduced correspondingly when the publicly-owned treatment works receiving the discharge is committed in its NPDES permit to remove a specified percentage of an incompatible pollutant
- The following wastes are not introduced into the publicly-owned treatment works:
  - --Pollutants which create a fire or explosion hazard in the POTW.
  - --Pollutants which will cause corrosive structural damage to the POTW, but in no case discharges with pH lower than 5.0, unless the works is specifically designed to accomodate such discharges.
  - --Solid or viscous pollutants in amounts which cause obstruction to the flow in sewers, or other interference with the operation of the POTW.
  - --Any pollutant, including oxygen demanding pollutants, released in a discharge or such volume or strength as to cause interference in the POTW.
  - --Heat in amounts which will inhibit biological activity in the POTW resulting in interference but in no case heat in such quantities that the temperature at the treatment works influent exceed 40 C (104 F) unless the works is designed to accomadate such heat.

These prohibitions are taken from the more general pretreatment standards set forth in 40 CFR Part 403 which are applicable as amended by the specific pretreatment standards for each point source category.

NPDES permits also impose special conditions beyond the effluent limitations stipulated, such as schedules of compliance and treatment standards. Once refineries are constructed in conformance with all applicable standards of performance, however, they are relieved by Section 306(d) of P.L. 92-500 from meeting any more stringent standards of performance for 10 years or during the period of depreciation or amortization, whichever ends first. This guarantee does not extend to toxic standards adopted under Section 307(a) of P.L. 92-500 which can be added to the refinery's NPDES permit when they are promulgated.

Many States have qualified, as permitted by Public Law 92-500, to administer their own NPDES permit programs. The major difference in obtaining an NPDES permit through approved State programs vis-a-vis the Federal NPDES permit system is that the FWPCA Amendments of 1972 do not extend the NEPA environmental impact review requirements to State programs. As of April 1976, Table 7 . Example of the application of size and process configuration factors for a new source.

Calculation of the Process Configuration

Process category	Processes included	Weighting factor
Crude	Atm. crude distillation. Vacuum crude distillation. Desalting.	1
Cracking and coking	Fluid cat. cracking. Vis-breaking. Thermal cracking. Moving bed cat. cracking. Hydrocracking. Fluid coking. Delayed coking.	6
Lube	Less than 12% of the feedstock throughput	13
Asphalt	Asphalt production. Asphalt oxidation. Asphalt emulsifying.	12

EXAMPLE.--Lube refinery 125,000 bbl per stream day throughput

Process	Capacity (1,000 bbl per stream day)	Capacity relative to throughput		Weighting factor		Processing configuration
Crude:						
Atm	125	1				
Vacuum	60	.48				
Desalting	125	1				
Total		2.48	X	1	=	2.48
Cracking-FCC	41	.328				
Hydrocracking	20	.160				
Total		.488	X	6	=	2.93
Lubes	5.3	.042				
	4.0	.032				
	4.9	.039				
Total		.113	X	13	=	1.47
Asphalt	4.0	0.032	X	12	=	.38
	Refinery process configuration				=	7.26

Table 7. Example of the application of the size and process configuration factors (Concluded).

Notes:

Using the Table for the Lube Subcategory on page 48 a feedstock through of 125 (1000 bbs/day); and a process configuration number of 7.26, it is seen that: process factor=0.88
size factor =0.97

To calculate the new source limits for each parameter multiply the applicable limits (from page 48) by both the process factor and the size factor. For example, the BOD_5 limit (maximum for any one day) is calculated as follows:

BOD_5 limit = 34.6 kg/1000 mg^3 (12.2 lb/1000 bbl) x .88 x .97 =
2915 kg/1000 mg^3 (10.4 lb/1000 bbl)

Table 8. Standards of performance for new sources applicable to the five subcategories of references.

TOPPING SUBCATEGORY	Effluent Limitations kg/1000 m^3 (lb/1000 bbl) of feedstock			
	Maximum for any one day		Average of daily values for 30 consecutive days shall not exceed	
BOD_5	11.8	(4.2)	6.3	(2.2)
TSS	8.3	(3.0)	4.9	(1.9)
COD[1]	61	(21.7)	32	(11.2)
Oil and grease	3.6	(1.3)	1.9	(.70)
Phenolic compounds	.088	(.031)	.043	(.016)
Ammonia as N	2.8	(1.0)	1.3	(.45)
Sulfide	.078	(.027)	.035	(.012)
Total chromium	.18	(.064)	.105	(.037)
Hexavalent chromium	.015	(.0052)	.0068	(.0025)
pH	Within the range 6.0 to 9.0			

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[1] In any case in which the applicant can demonstrate that the chloride ion concentration in the effluent exceeds 1,000 mg/l (1,000 ppm), the Regional Administrator may substitute TOC as a parameter in lieu of COD. Effluent limitations for TOC shall be based on effluent data from the plant correlating TOC to BOD_5.

If in the judgment of the Regional Administrator, adequate correlation data are not available, the effluent limitations for TOC shall be established at a ratio of 2.2 to 1 to the applicable effluent limitations on BOD_5.

Table 8. Standards of performance for new sources applicable to the five subcategories of references (Continued).

Size factor.

1,000 bbl of feedstock per stream day:	Size factor
Less than 24.9	1.02
25.0 to 49.9	1.06
50.0 to 74.9	1.16
75.0 to 99.9	1.26
100.0 to 124.9	1.38
125.0 to 149.9	1.50
150.0 or greater	1.57

Process factor.

Process Configuration	Process factor
Less than 24.9	0.62
2.5 to 3.49	0.67
3.5 to 4.49	0.80
4.5 to 5.49	0.95
5.5 to 5.99	1.07
6.0 to 6.49	1.17
6.5 to 6.99	1.27
7.0 to 7.49	1.39
7.5 to 7.99	1.51
8.0 to 8.49	1.64
8.5 to 8.99	1.79
9.0 to 9.49	1.95
9.5 to 9.99	2.12
10.0 to 10.49	2.31
10.5 to 10.99	2.51
11.0 to 11.49	2.73
11.5 to 11.99	2.98
12.0 to 12.49	3.24
12.5 to 12.99	3.53
13.0 to 13.49	3.84
13.5 to 13.99	4.18
14.0 or greater	4.36

(a) Runoff

The allocation allowed for storm runoff flow, as kg/cu m (lb/Mgal), shall be based solely on that storm flow (process area runoff) which is treated in the main treatment system. All additional storm runoff (from tankfields and non-process areas), that has been segregated from the main waste stream for discharge, shall not exceed a concentration of 35mg/l of TOC or 15 mg/l of oil and grease when discharged. The following allocations for runoff are in addition to the process discharge allowed by the above limitations:

Table 8. Standards of performance for new sources applicable to the five subcategories of references (Continued).

(a) Runoff continued

	Effluent Limitations kg/1000 m^3 (lb/1000 gal) of flow			
	Maximum for any one day		Average of daily values for 30 consecutive days shall not exceed	
BOD$_5$	0.048	(0.40)	0.026	(.21)
TSS	.033	(.27)	.021	(.17)
COD^1	.37	(3.1)	.19	(1.6)
Oil and grease	.015	(.126)	.0080	(.067)
pH	Within the range 6.0 to 9.0			

(b) Ballast

The allocation allowed for ballast water flow, as kg/cu m (lb/M gal), shall be based on those ballast waters treated at the refinery. The following allocations are in addition to the process and runoff limitations:

	Effluent Limitations kg/1000 m^3 (lb/1000 gal) of flow			
	Maximum for any one day		Average of daily values for 30 consecutive days shall not exceed	
BOD$_5$	0.048	(.40)	0.026	(.21)
TSS	.033	(.27)	.021	(.17)
COD^1	.47	(3.9)	.24	(2.0)
Oil and grease	.15	(.126)	.008	(.067)
pH	Within the range 6.0 to 9.0			

(c) Cooling water

Once through cooling water may be discharged with a total organic carbon concentration not to exceed 5 mg/l.

Note: The above provisions relating to runoff, ballast, and once through cooling water also are applicable to the cracking, petrochemical, lube, integrated subcategories.

Table 8. Standards of performance for new sources applicable to the five subcategories of references (Continued)

CRACKING SUBCATEGORY

	Effluent Limitations kg/1000 m^3 (lb/1000 bbl) of feedstock			
	Maximum for any one day		Average of daily values for 30 consecutive days shall not exceed	
BOD$_5$	16.3	(5.8)	8.7	(3.1)
TSS	11.3	(4.0)	7.2	(2.5)
COD[1]	118	(41.5)	61	(21.0)
Oil and grease	4.8	(1.7)	2.6	(.93)
Phenolic compounds	.119	(.042)	.058	(.020)
Ammonia as N	18.8	(6.6)	8.6	(3.0)
Sulfide	.105	(.037)	.048	(0.17)
Total chromium	.24	(.084)	.14	(.049)
Hexavalent chromium	.020	(.0072)	.0088	(.0032)

pH Within the range 6.0 to 9.0

Size Factor.

1,000 bbl of feedstock per stream day:	Size factor
Less than 2.49	0.91
25.0 to 49.9	0.95
50.0 to 74.9	1.04
75.0 to 99.9	1.13
100.0 to 124.9	1.23
125.0 to 149.9	1.35
150.0 or greater	1.41

Process Factor.

Process configuration:	Process factor
Less than 2.49	0.58
2.5 to 3.49	0.63
3.5 to 4.49	0.74
4.5 to 5.49	0.88
5.5 to 5.99	1.00
6.0 to 6.49	1.09
6.5 to 6.99	1.19
7.0 to 7.49	1.29
7.5 to 7.99	1.41
8.0 to 8.49	1.53
8.5 to 8.99	1.67
9.0 to 9.49	1.82
9.5 or greater	1.89

Table 8. Standards of performance for new sources applicable to the five subcategories of references (Continued).

PETROCHEMICAL SUBCATEGORY	Effluent Limitations kg/1000 m^3 (lb/1000 bbl) of feedstock			
	Maximum for any one day		Average of daily values for 30 consecutive days shall not exceed	
BOD_5	21.8	(7.7)	11.6	(4.1)
TSS	14.9	(5.2)	9.5	(3.3)
COD[1]	133	(47.0)	69	(24.0)
Oil and grease	6.6	(2.4)	3.5	(1.3)
Phenolic compounds	.158	(.056)	.077	(.027)
Ammonia as N	23.4	(8.3)	10.7	(3.8)
Sulfide	.140	(.050)	.063	(.022)
Total chromium	.32	(.116)	.19	(.068)
Hexavalent chromium	.025	(.0096)	.012	(.0044)
pH Within the range 6.0 to 9.0				

Size factor.

1,000 bbl of feedstock per stream day:	Size factor
Less than 24.9	0.73
25.0 to 49.9	0.76
50.0 to 74.9	0.83
75.0 to 99.9	0.91
100.0 to 149.9	1.08
150.0 or greater	1.13

Process factor.

Process configuration:	Process factor
Less than 4.49	0.73
4.5 to 5.49	0.80
5.5 to 5.99	0.91
6.0 to 6.49	0.99
6.5 to 6.99	1.08
7.0 to 7.49	1.17
7.5 to 7.99	1.28
8.0 to 8.49	1.39
8.5 to 8.99	1.51
9.0 to 9.49	1.65
9.5 or greater	1.72

Table 8. Standards of performance for new sources applicable to the five subcategories of references (Continued.)

LUBE SUBCATEGORY

	Effluent Limitations kg/1000 m^3 (lb/1000 bbl) of feedstock			
	Maximum for any one day		Average of daily values for 30 consecutive days shall not exceed	
BOD_5	34.6	(12.2)	18.4	(6.5)
TSS	23.4	(8.3)	14.9	(5.3)
COD[1]	245.0	(87.0)	126.0	(45.0)
Oil and grease	10.5	(3.8)	5.6	(2.0)
Phenolic compounds	.25	(.088)	.12	(.043)
Ammonia as N	23.4	(8.3)	10.7	(3.8)
Sulfide	.220	(.078)	.10	(.035)
Total chromium	.52	(.180)	.31	(.105)
Hexavalent chromium	.046	(.022)	.021	(.0072)
pH	Within the range 6.0 to 9.0			

Size factor.

1,000 bbl of feedstock per stream day:	Size factor
Less than 49.9	0.71
50.0 to 74.9	0.74
75.0 to 99.9	0.81
100.0 to 124.9	0.88
125.0 to 149.9	0.97
150.0 to 174.9	1.05
175.0 to 199.9	1.14
200.0 or greater	1.19

Process factor

Process configuration:	Process factor
Less than 6.49	0.81
6.5 to 7.49	0.88
7.5 to 7.99	1.00
8.0 to 8.49	1.09
8.5 to 8.99	1.19
9.0 to 9.49	1.29
9.5 to 9.99	1.41
10.0 to 10.49	1.53
10.5 to 10.99	1.67
11.0 to 11.49	1.82
11.5 to 11.99	1.98
12.0 to 12.49	2.15
12.5 to 12.99	2.34
13.0 or greater	2.44

Table 8. Standards of performance for new sources applicable to the five subcategories of references (Concluded).

INTEGRATED SUBCATEGORY	Effluent Limitations kg/1000 m^3 (lb/1000 bbl) of feedstock			
	Maximum for any one day		Average of daily values for 30 consecutive days shall not exceed	
BOD_5	41.6	(14.7)	22.1	(7.8)
TSS	28.1	(9.9)	17.9	(6.3)
COD[1]	295	(104.0)	152	(54.0)
Oil and grease	12.6	(4.5)	6.7	(2.4)
Phenolic compounds	.30	(.105)	.14	(.051)
Ammonia as N	23.4	(8.3)	10.7	(3.8)
Sulfide	.26	(093)	.12	(0.042)
Total chromium	.64	(.220)	.37	(.13)
Hexavalent	.052	(.019)	.024	(.0084)
pH	Within the range 6.0 to 9.0			

Size factor.

1,000 bbl of feedstock per stream day:	Size factor
Less than 124.9	0.73
125.0 to 149.9	0.76
150.0 to 174.9	0.83
175.0 to 199.9	0.91
200.0 to 224.9	0.99
225 or greater	1.04

Process factor.

Process configuration:	Process factor
Less than 6.49	0.75
6.5 to 7.49	0.82
7.5 to 7.99	0.92
8.0 to 8.49	1.00
8.5 to 8.99	1.10
9.0 to 9.49	1.20
9.5 to 9.99	1.30
10.0 to 10.49	1.42
10.5 to 10.99	1.54
11.0 to 11.49	1.68
11.5 to 11.99	1.83
12.0 to 12.49	1.99
12.5 to 12.99	2.17
13.0 or greater	2.26

however, 26 States had enacted NEPA-type legislation and others plan to do so. Thus it is likely that new refineries or major expansions of existing refineries will come under increased environmental review in the future. Because the scope of the implementing regulations varies considerably, current information on prevailing requirements should be obtained early in the planning process from permitting authorities in the appropriate jurisdiction.

I.F.2. Air Pollution Performance Standards

Air pollution regulations specify both the amount of various pollutants that can be emitted from a source and standards for pollution of ambient air. The paragraphs which follow discuss these regulations.

New source performance standards (NSPS) applicable to several sources of air pollution from petroleum refineries are promulgated in 40 CFR 60, subpart J and K. Subpart J imposes emission limitations on fluid catalytic cracking unit catalyst regenerators, fuel gas combustion devices, and all Claus sulfur recovery plants (except recovery plants of 20 long tons per day or less associated with a small refinery). Subpart K regulates the storage of petroleum, condensate, and finished or intermediate products (with the exception of most fuel oils) in order to control hydrocarbon emissions.

The storage NSPS only apply to storage vessels of greater than 151,412 liters (40,000 gal.) except:

- Pressure vessels designed to operate in excess of 6.8kg per cm^2 (15 psi) gauge without emissions except under emergency conditions
- Subsurface caverns or reservoirs
- Underground tanks if the total volume added to and taken from a tank annually does not exceed twice the volume of the tank

In contrast to other NSPS's, the standards for storage vessels do not place specific limitations on hydrocarbon emissions, and instead require the installation and use of specified equipment. A floating roof, vapor recovery system, or equivalent is required for storage vessels when the true vapor pressure of the liquid stored is equal to or greater than 78 mm Hg (1.5 psia) but not greater than 570 mm Hg (11.1 psia). A vapor recovery system or equivalent is required when the vapor pressure exceeds the latter value. Some gasolines and gasoline feedstocks, for example, would fall in this category. The applicant should note that any device capable of providing comparable hydrocarbon emission control may be substituted for the specified device. These regulations currently are undergoing review to determine whether or not revisions are needed.

The sulfur dioxide NSPS for fuel gas combustion systems in refineries limits SO_2 emissions to the atmosphere by specifying that the fuel gas combusted shall contain no more than 230 milligrams per dry standard cubic meter (mg/dscm) (0.10 grain per dry standard cubic foot) (gr/dscf) of hydrogen sulfide. Compliance with the standard also will be permitted by effectively removing SO_2 from the stack gases instead of removing H_2S from the fuel gas. Fuel gas is defined as any gas produced by a process unit and combusted except process upset gas.

SO_2 standards applicable to Claus sulfur recovery plants, which process gases produced within a petroleum refinery regardless of whether the plant is physically located within the refinery, are as follows:

- 0.025% by volume of sulfur dioxide at 0% oxygen on a dry basis if emissions are controlled by an oxidation control system, or a reduction control system followed by incineration; or
- 0.030% by volume of reduced sulfur compounds and 0.0010% by volume of hydrogen sulfide calculated as sulfur dioxide at 0% oxygen on a dry basis if emissions are controlled by a reduction control system not followed by incineration.

Particulate matter emitted from fluid catalytic cracking unit catalyst regenerators is limited to 1.0 kilogram (kg)/1000 kg (1.0 lb/1000 lb) of coke burnoff. When the gases from the regenerator pass through an incinerator or waste heat boiler in which oil or coal is burned as an auxiliary fuel, this limitation may be exceeded except that the incremental rate of emissions may not exceed 43.0 gram (g)/MS (0.10 lb/million Btu) of heat input attributable to the auxiliary fuel.

The opacity of catalyst regenerator gases is limited to less than 30% except for six minutes in any one hour or when greater opacity is due to the presence of uncombined water. The opacity standard is a backup means to ensure that control equipment always is maintained and operated properly. The NSPS limit on the CO content of the regenerator emission is 0.050% by volume.

Screening studies preliminary to establishing NSPS are being completed on vacuum distillation and other miscellaneous sources (e.g., leaks) in refineries. Projections on future NSPS action on these sources currently are not available.

The above NSPS for air applicable to new source refineries have undergone several revisions, which indicates that these regulations are far from static. Applicants, therefore, should determine the most recent status of the various air regulations, early in the planning process.

Applicants also should be current on the status of national emission standards for hazardous air pollutants (NESHAP) promulgated under Section 112 of the Clean Air Act. To date only five materials have been declared as hazardous pollutants: asbestos, beryllium, mercury, polyvinyl chloride, and benzene. EPA is examining other substances for possible inclusion in this classification. Also, although present standards only apply to specific processes which generate concentrated emissions of these pollutants, EPA is emphasizing control of trace toxic emissions.

The effects of the national ambient air quality standards (NAAQS) on construction of expansion of refinery capacity also should be ascertained. Since the Clean Air Act requires States to enact State Implementation Plans (SIP's) for attaining the NAAQS, these standards may exert a strong influence on the siting of new facilities. The primary and secondary standards designed to protect public health and welfare respectively are shown in Table 9. NAAQS for sulfur dioxide and particulates assume special importance in both pristine areas where the air quality is cleaner than the levels of these standards and in areas where the standards are being exceeded.

Table 9. Summary of National Ambient Air Quality Standards (from 40 CFR 50)

Emission	Standard Primary	Standard Secondary
Sulfur dioxide	80 micrograms/m^3 annual arithmetic mean	1,300 micrograms/m^3 maximum 3-hour concentration*
	365 micrograms/m^3 maximum 24-hour concentration*	
Particulate matter	75 micrograms/m^3 annual geometric mean	150 micrograms/m^3 maximum 24-hour concentration*
	260 micrograms/m^3 maximum 24-hour concentration*	60 micrograms/m^3 annual geometric mean (as guide in assessing implementation plans)
Hydrocarbons	160 micrograms/m^3 (0.24 ppm) maximum 3-hour concentration *	160 micrograms/m^3 (0.24 ppm) maximum 3-hour concentration*
Nitrogen dioxide	100 micrograms/m^3 annual arithmetic mean	100 micrograms/m^3 annual arithmetic mean
Ozone	235 micrograms/m^3 (0.12 ppm) maximum 1-hour concentration*	235 micrograms/m^3 (0.12 ppm) maximum 1-hour concentration*
Carbon monoxide	10 mg/m^3 (9 ppm) maximum 8-hour concentration*	10 mg/m^3 (9 ppm) maximum 8-hour concentration*
	40 mg/m^3 (35 ppm) maximum 1-hour concentration*	40 mg/m^3 (35 ppm) maximum 1-hour concentration*
Lead	1.5 micrograms/m^3 maximum calendar quarterly average	1.5 micrograms/m^3 maximum calendar quarterly average

*The maximum allowable concentration may be exceeded for the prescribed period once each year without violating the standard.

In 1974, the Environmental Protection Agency (EPA) issued regulations for the prevention of significant deterioration of air quality (PSD) under the 1970 version of the Clean Air Act (Public Law 90-604). These regulations established a plan for protecting areas that possess air quality which is cleaner than the National Ambient Air Quality Standards (NAAQS). Under EPA's regulatory plan, clean air areas of the Nation could be designated as one of three "Classes." The plan permitted specified numerical "increments" of air pollution increases from major stationary sources for each class, up to a level considered to be "significant" for that area. Class I provided extraordinary protection from air quality deterioration and permitted only minor increases in air pollution levels. Under this concept, virtually any increase in air pollution in the above pristine areas would be considered significant. Class II increments permitted increases in air pollution levels such as would usually accompany well-controlled growth. Class III increments permitted increases in air pollution levels up to the NAAQS.

Sections 160-169 were added to the Act by the Clean Air Act Amendments of 1977. These amendments adopt the basic concept of the above administratively developed procedure of allowing incremental increases in air pollutants by class. Through these amendments, Congress also provided a mechanism to apply a practical adverse impact test which did not exist in the EPA regulations.

The PSD requirements of 1974 applied only to two pollutants: total suspended particulates (TSP) and sulfur dioxide (SO_2) (See Table 10). However, Section 166 requires EPA to promulgate PSD regulations by 7 August 1980 addressing nitrogen oxides, hydrocarbons, carbon monoxide, and photochemical oxidants utilizing increments or other effective control strategies. For these additional pollutants, States may adopt non-increment control strategies which, if taken as a whole, accomplish the purposes of PSD policy set forth in Section 160.

Whereas the earlier EPA regulatory process had not resulted in the Class I designation of any Federal lands, the 1977 Amendments designated certain Federal lands Class I. All international parks and national memorial parks and national parks exceeding 5,000 acres, are designated Class I. These 158 areas may not be redesignated to another class through State or adminstrative action. The remaining areas of the county are initially designated Class II. Within this Class II category, certain national primitive areas, national wild and scenic rivers, national wildlife refuges, national seashores and lakeshores, and new national park and wilderness areas which are established after 7 August 1977, if over 10,000 acres in size are Class II "floor areas" and are ineligible for redesignation to Class III.

Although the earlier EPA regulatory process allowed redesignation by the Federal land manager, the 1977 amendments place the general redesignation responsibility with the States. The Federal land manager only has an advisory role in the redesignation process, and may recommend redesignation to the appropriate State or to Congress.

In order for Congress to redesignate areas, proposed legislation would be introduced. Once proposed, this would probably follow the normal legislative process of committee hearings, floor debate, and action. In order for a State to redesignate areas, the detailed process outlined in Section 164(b)

Table 10. Nondeterioration increments for particulate matter and for SO$_2$ by area air quality classifications.

Pollutant*	Class I (μg/m^3)	Class II (μg/m^3)	Class III (μg/m^3)	Class I' increment (μg/m^3)
Particulate matter:				
Annual geometric mean	5	19	37	19
24-hour maximum	10	37	75	37
Sulfur dioxide:				
Annual arithmetic mean	2	20	40	20
24-hour maximum	5**	91	182	91
3-hour maximum	25**	512	700	325

*Other pollutants for which PSD regulations will be promulgated are to include hydrocarbons, carbon monoxide, photochemical oxidants, and nitrogen oxides.

**A variance may be allowed to exceed each of these increments on 18 days per year, subject to limiting 24-hour increments of 36 μg/m^3 for low terrain and 62 μg/m^3 for high terrain and 3-hour increments of 130 μg/m^3 for low terrain and 221 μg/m^3 for high terrain. To obtain such a variance both State and Federal approval is required.

Source: Public Law 95-95. 1977. Clean Air Act Amendments of 1977, Part C, Subpart 1, Section 163 (Passed August 1977).

would be followed. This would include an analysis of the health, environmental, economic, social, and energy effects of the proposed redesignation to be followed by a public hearing.

Class I status provides protection to areas by requiring any new major emitting facility (generally a large point source of air pollution--see Section 169(1) for definition) in the vicinity to be built in such a way and place as to insure no adverse impact on the Class I air quality related values.

The permit may be issued if the Class I increment will not be exceeded, unless the Federal land manager demonstrates to the satisfaction of the State that the facility will have an adverse impact on the Class I air quality related values.

The permit must be denied if the Class I increment will be exceeded, unless the applicant receives certification from the Federal land manager that the facility will not adversely affect Class I air quality related values.

Non-attainment provisions of the Clean Air Act, as interpreted in a ruling of 21 December 1976 (41 Federal Register 40; 55524), stipulate that a major new source may locate in an area with air quality worse than a national standard (non-attainment area) only if stringent conditions be met. These conditions are designed to ensure that emissions from the new source will be controlled to the greatest degree possible (lowest achievable emission rate); that more than equivalent offsetting emission reductions (emission offsets) will be obtained from existing sources; and that there will be progress toward achievement of the standard. For the purposes of this ruling, a major source is defined as one having an allowable emission rate of 100 or more tons per year of a pollutant (1,000 tons for carbon monoxide). The lowest achievable emission rate, at a minimum, must correspond to the lowest rate achieved in practice and must not exceed any applicable new source performance standard.

According to the Prevention of Significant Deterioration (PSD) provisions of the Clean Air Act, a proposal for the construction of a major new source or a major modification to an existing source (allowable emission increase of 50 tons or more per year) must undergo a preconstruction review. This review requires the application of the best available control technology, ambient air quality monitoring, emission modeling, and various other assessments. Emission modeling must show that the new source or modification will not cause increases in ambient pollutant concentrations greater than allowable increments specified in the PSD provisions and will not cause violations of any National Ambient Air Quality Standard.

The Clean Air Act also contains provisions regarding the use of tall stacks or other dispersion techniques for complying with ambient air standards. The height of a stack should be based on good engineering practice; it should not exceed the height necessary to ensure that emissions do not result in excessive concentrations in the immediate vicinity of the source as a result of atmospheric downwash, eddies, and wakes, created by the source (2½ times the height of the source), nearby structures, or terrain. Other dispersion techniques, including any intermittent or supplemental control of air pollutants varying with atmospheric conditions, may not be employed.

I.F.3 Land Disposal of Wastes

The disposal of hazardous and non-hazardous wastes on land are regulated under the Federal Resource Conservation and Recovery Act of 1976 (RCRA) (P.L. 94-580), either by EPA or by a State with an approved state program.

Disposal of non-hazardous wastes on land will require the use of sanitary landfills because disposal sites classified as open dumps are prohibited. A site can be classified as a sanitary landfill only if disposal of wastes at the site would pose no reasonable probability of adverse effects on health or the environment.

Hazardous wastes are identified in 40 CFR 261 Subpart D. The hazardous substances identified at this time in Subpart D include the major solid wastes of the petroleum industry.

All new facilities that will generate, transport, treat, store, or dispose of hazardous wastes must notify USEPA of this occurence and obtain a USEPA identification number. Storage, treating, and disposal also require a permit.

The determination of whether wastes generated or handled are hazardous is the responsibility of the owner or operator of the generating or handling facility. The first step is to consult the promulgated list (40 CFR 261, Subpart D). Dissolved air flotation float, for example, is listed as a hazardous waste. If the waste is not listed, the second step is to determine whether the waste exhibits any of the hazardous characteristics of listed through analytical tests using procedures promulgated in the regulations of by applying known information about characteristics of the waste based on process or materials used.

If it is determined that a hazardous waste is generated, it should be quantified to determine applicability of the small generator exemption. This cutoff point is 2,200 pounds per month, but it drops to 2.2 pounds for any commercial product or manufacturing chemical intermediate having a generic name listed in Section 261.33. Containers that have been used to contain less than 21 quarts of Section 261.33 materials and less than 22 pounds of liners from such containers are also exempt. It is anticipated that this exemption may be available to many very small plants with, for example, only one machine tool and one small painting operation. However, as more information is obtained on the behavior of substances in a disposal environment, the terms of this exemption may be altered from time to time.

The hazardous waste management system is based on the use of a manifest prepared by the generator describing and quantifying the waste and designating a disposal, treatment, or storage facility permitted to receive the type waste described to which the waste is to be delivered. One alternate site may be designated. Copies of the manifest are turned over to the transporter and a copy must be signed and returned to the generator each time the waste changes hands. If the generator does not receive a copy from the designated receiving facility or alternate within 35 days, he must track the fate of the waste through the transporter and designated facility or facilities. If the manifest copy is not received in 45 days, the generator must file an Exception Report with USEPA or the cognizant state agency.

A copy of each manifest must be kept for three years or until a signed copy is received from the designated receiving facility. In turn, the signed copy must be kept for three years. The same retention period applies to each Annual Report required whether disposal, storage, or treatment occurs on-site or off-site.

The generator must also:

- package the waste in accordance with the applicable DOT regulations under 49 CFR Parts 173, 178, and 179;
- label each package in accordance with DOT regulations under 49 CFR 172;
- mark each package in accordance with the applicable DOT regulations under 49 CFR 172;
- mark each container of 110 gallons or less with the following DOT (49 CFR 172) notice:

  > "Hazardous Waste - Federal Law Prohibits Improper Disposal. If found, contact the nearest police or public safety authority or the U.S. Environmental Protection Agency."

- supply appropriate placards for the transporting vehicle in accordance with DOT regulations under 49 CFR Part 172, Subpart F.

Waste in properly labelled and dated containers in compliance with the regulations may be stored on the generator's premises for up to 90 days without a storage permit. This is to permit time for accumulation for more economic pickup or to find an available permitted disposal facility.

Due to the cost and stringent design and operating requirements for permitted landfills, it is anticipated that most new generator plants will utilize off-site disposal facilities. However, any companies desiring to construct their own will be subject to 40 CFR Part 264.

Incineration is considered to be "treatment," and, as such, is also subject to Part 264 as are chemical, physical, and biological treatment of hazardous wastes, and a permit will be required. Totally enclosed treatment systems--such as in-pipe treatment of acid and alkaline solutions--are not subject to this part.

Although underground injection of wastes constitutes "disposal" as defined by RCRA, this activity will be regulated by the underground injection control (UIC) program adopted pursuant to the Safe Drinking Water Act (P.L. 93-523). The consolidated permit regulations (40 CFR Parts 122, 123, 124) govern the procedural aspects of this program; the technical considerations are contained in 40 CFR Part 146.

II. IMPACT IDENTIFICATION

A variety of impacts may result from waste streams generated by typical petroleum refinery operations. These process operations were described in some detail in Section 1.B. The sections that follow outline the major waste streams (water, air, solid waste), pollutant sources, pollutant loads and the potential environmental impacts that should be addressed in the EID for a new source oil refinery.

II.A. PROCESS WASTES (EFFLUENTS)

Refineries are substantial dischargers of wastewaters. Further, these wastewaters generally have high concentrations of tars, oils and dissolved organics. Frequently a large fraction of the dissolved organics are not readily biodegradable. Spent catalysts, containing large amounts of heavy metals may create serious problems for waste treatment systems and the environment. Many chemicals which may be found in refinery effluents such as styrene, benzene, anthracene and phenol are believed to be toxic if they reach life forms in harmful concentrations. Therefore, it is necessary for the permit applicant to include best estimates for at least the following:

- All effluent streams (sources, quantities, flow composition)
- Frequency and duration of wasteflows and variations in composition
- Potential toxic chemicals
- Biological/chemical characteristics of all receiving waters and their use patterns

II.A.1. Various Liquid Waste Sources

II.A.1.a. Raw Materials

The most significant environmental problems associated with raw materials result from the transport, handling, and storage of the crude oil.

During handling, transportation and storage of crude oil and products, residues can impact waste streams through spills and leaks, tank-cleaning operations, and ballast waters from tankers, which in turn, can affect environmental quality. Oil, finished product, water and other residues on storage tank bottoms (i.e., product, intermediate, and crude storage tanks) are potential sources of wastewaters. Filters and filter media also can contribute to waste streams. These waste streams could adversely affect streams, estuarine and coastal waters.

Relative to crude oil constituents, sulfur and sulfur compounds constitute the most significant contaminants in crude oil fractions. Oxygen compounds, nitrogen compounds and metal compounds of vanadium, nickel, iron, calcium, mangesium, aluminum, copper, sodium, potassium, arsenic, and zinc are other compounds which can present treating problems and potential environmental degradation. Of the metals, vanadium, nickel and iron are the most significant because they shorten the life of hydrodesulfurization catalysts. Polynuclear aromatic hydrocarbons are important constituents and are known to be toxic and/or carcinogenic.

Further, the sulfur content of crude oil is not distributed uniformly throughout the boiling range of the oil, but is concentrated progressively in the higher boiling fractions. The types of sulfur compounds present in crude oils also vary. Over one hundred sulfur compounds have been identified through analyses of only three crude oils (Rall, et al. 1962). During the past three years, however, increasingly severe environmental restrictions have been placed on sulfur recovery units themselves (Claus process) in terms of emission controls.

II.A.1.b. Process Wastes[4]

Figure 6 shows basic oil refinery operations and the general character of their respective wastes; the diagram includes operations typical of a complete refinery (i.e., a refinery that manufactures motor fuels, burning oils, lubricating oils and greases, waxes, asphalts and speciality products).

Because a multiplicity of potential pollutants may be generated from an integrated refinery operation, for these guidelines, they have been categorized generally as follows:

- Free oil
- Emulsified oil
- Condensate waters
- Acid wastes
- Waste caustics
- Alkaline waters
- Special chemicals
- Waste gases
- Sludges and other solids
- Clean cooling water
- Sanitary wastes

The various wastes that may pollute the environment usually originate in small quantities from a large number of sources which are distributed widely throughout the refinery. The sources and characteristics of the various types of wastes that have potential to significantly effect the environment are described below.

II.A.1.c. Free Oil

Depending on the efficiency of pollution control measures used, large integrated refineries may be expected to have varying amounts of their crude oil charge escape to the sewers in the form of free oil.

The presence of light ends creates a potential explosion hazard in the sewers. For this reason precaution should be taken in the design of the sewerage system to adequately trap all sewer inlets.

Oil exists in the wastewater in three fractions:

- Suspended fraction (small droplets, small solids-oil agglomerates, oil in water emulsion)
- Floating fraction (water in oil emulsion or free oil)
- Settleables

In practically all cases gravity differential oil-water separators are provided to recover floating oil and to treat the waste. In the process of separating oil from water, oil rises to the surface, sediment (containing oils) settles to the bottom and relatively small concentrations of oil and suspended solids pass through the separator. Some solid matter rises to the

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[4] This summary discussion is based largely on the following more detailed source documents: USEPA 1976 a-d; 1967 Ind. Waste Treatment, USEPA 1973.

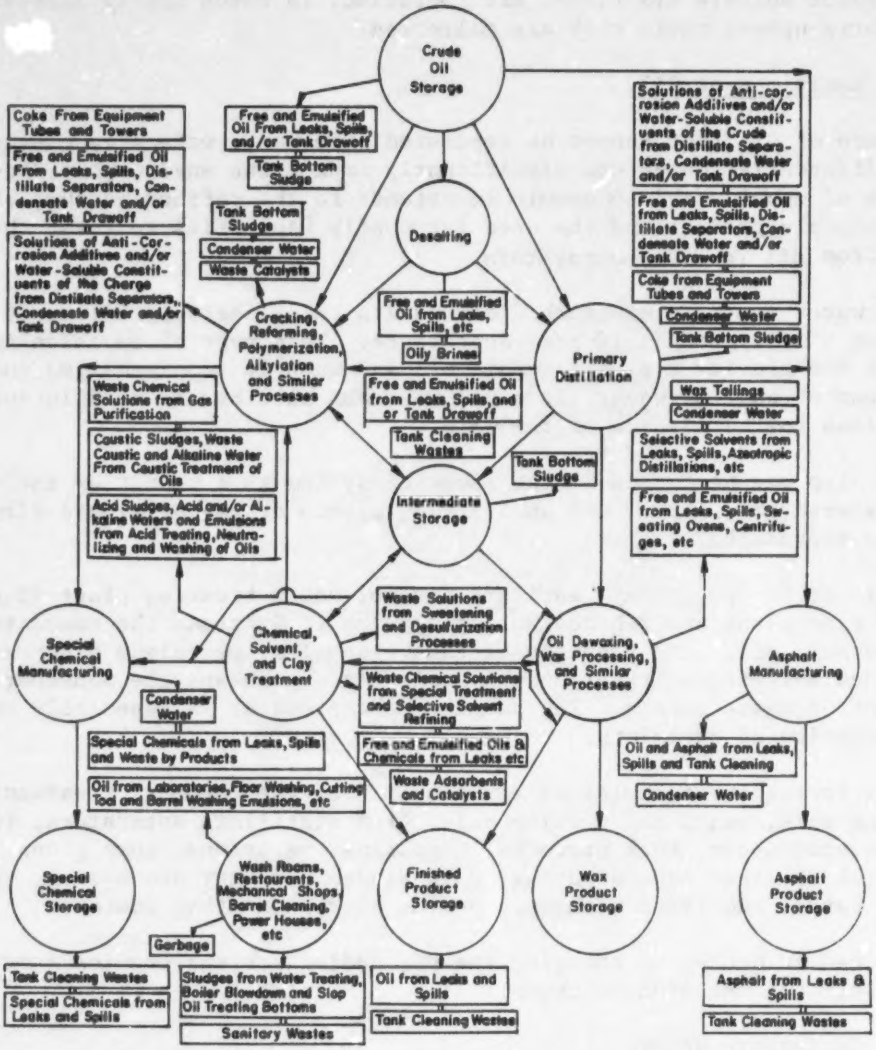

Crude Oil Storage
Free and Emulsified Oil From Leaks, Spills, and/or Tank Drawoff
Tank Bottom Sludge
Coke From Equipment Tubes and Towers
Free and Emulsified Oil From Leaks, Spills, Distillate Separators, Condensate Water and/or Tank Drawoff
Solutions of Anti-Corrosion Additives and/or Water-Soluble Constituents of the Charge from Distillate Separators, Condensate Water and/or Tank Drawoff
Tank Bottom Sludge
Condenser Water
Waste Catalysts
Desalting
Solutions of Anti-corrosion Additives and/or Water-Soluble Constituents of the Crude from Distillate Separators, Condensate Water and/or Tank Drawoff
Free and Emulsified Oil from Leaks, Spills, Distillate Separators, Condensate Water and/or Tank Drawoff
Coke from Equipment Tubes and Towers
Condenser Water
Tank Bottom Sludge
Free and Emulsified Oil from Leaks, Spills, etc
Oily Brines
Cracking, Reforming, Polymerization, Alkylation and Similar Processes
Primary Distillation
Free and Emulsified Oil from Leaks, Spills, and or Tank Drawoff
Tank Cleaning Wastes
Waste Chemical Solutions from Gas Purification
Caustic Sludges, Waste Caustic and Alkaline Water From Caustic Treatment of Oils
Acid Sludges, Acid and/or Alkaline Waters and Emulsions from Acid Treating, Neutralizing and Washing of Oils
Tank Bottom Sludge
Intermediate Storage
Wax Tailings
Condenser Water
Selective Solvents from Leaks, Spills, Azeotropic Distillations, etc
Free and Emulsified Oil from Leaks, Spills, Sweating Ovens, Centrifuges, etc
Waste Solutions from Sweetening and Desulfurization Processes
Special Chemical Manufacturing
Chemical, Solvent, and Clay Treatment
Oil Dewaxing, Wax Processing, and Similar Processes
Asphalt Manufacturing
Condenser Water
Waste Chemical Solutions from Special Treatment and Selective Solvent Refining
Free and Emulsified Oils & Chemicals from Leaks etc
Waste Adsorbents and Catalysts
Special Chemicals from Leaks, Spills and Waste by Products
Oil from Laboratories, Floor Washing, Cutting Tool and Barrel Washing Emulsions, etc
Oil and Asphalt from Leaks, Spills and Tank Cleaning
Condenser Water
Special Chemical Storage
Wash Rooms, Restaurants, Mechanical Shops, Barrel Cleaning, Power Houses, etc
Finished Product Storage
Wax Product Storage
Asphalt Product Storage
Garbage
Tank Cleaning Wastes
Special Chemicals from Leaks and Spills
Sludges from Water Treating, Boiler Blowdown and Slop Oil Treating Bottoms
Sanitary Wastes
Oil from Leaks and Spills
Tank Cleaning Wastes
Asphalt from Leaks & Spills
Tank Cleaning Wastes

Figure 6. Typical wastes produced in a complete petroleum refinery.

surface with the oil and some oil settles to the bottom with the solids. It also should be noted that gravity differential oil-water separators cannot remove oil in the form of oil in water emulsions or in the form of oil-suspended solids agglomerates with specific gravities approximately that of the water or water soluble fractions, air flotation, in which finely divided air bubbles carry upward where they are collected.

II.A.1.d. Emulsions of Oil

The presence of oil that cannot be separated from waste waters by conventional gravity differential means can significantly impact the environment; however, it also is of considerable economic importance to the refiner because of the loss of valuable product and the need for costly facilities to treat the effluent from oil recovery separators.

An oil in water emulsion has turbididty as its chief characteristic and usually has a milky or pearly-gray appearance. This type of emulsion is not removed in the gravity type oil separator, and when it is discharged into a large stream or body of water, it usually breaks as a result of dilution and the oil rises to the surface of the water.

Emulsions also may be formed in the sewerage system as a result of intimate contact between oil, water, and emulsifying agents or may originate directly as process byproducts.

The occurrence of coke, clay, sanitary sewage, water treating plant sludges and other flocculent and fibrous solids appears to increase the concentration of nonseparable oil. The presence of tars, asphalts, petroleum sludges, soaps and numerous solvent and treating chemicals also increases the nonseparable oil content of waste waters. The pumping of wastewater is especially conducive to the formation of emulsions.

The direct formation of emulsions may result from the chemical treatment of lubricating oils, waxes and burning oils, from distillate separators, from barometric condensors, tank drawoffs, desalting operations, pump gland leakage, special chemical manufacturing, acid sludge recovery processing, wax deoiling, barrel and truck washing, machine shops and other sources.

Emulsions can be broken by changing the pH, adding various chemicals or the use of electrical emission breakers.

II.A.1.e. Condensate Waters

Condensate waters originate from distillate separators, running tanks, and barometric condensers. It has been reported (Teague 1950) that condensate waters from distillate separators may contain one or more of such compounds as organic and inorganic sulfides, normal or acid sulfites and sulfates, sulfonic acids and their salts, mercaptans, amines, amides, quinalines and pyridines, napthenic acids, phenols, etc. They also may contain chemicals used for corrosion prevention such as ammonia, caustic soda, calcium hydroxide, etc. Not all these substances will be found in a specific wastewater at the same time. Waste of this type also may contain suspended matter such as coke, iron sulfide, silica, metallic oxides, soaps, emulsions, sulfonic and naphthenic acids, insoluble mercaptides and other suspended solids (Teague 1950).

II.A.1.f. Acid Wastes

Sulfuric acid is used extensively in the petroleum industry both as a treating agent and a catalyst. Other acids and acid salts also used as catalysts include hydrofuoric acid, phosphoric acid, aluminum chloride and zinc chloride. Acid bearing wastes originate form the acid treatment of gasoline, white oils, lubricating oils and waxes; from the handling of acid sludges and the recovery or manufacture of acid; from the alkylation of motor fuel stocks; from the use of acidic catalysts; and from special chemical manufacturing.

II.A.1.g. Waste Caustics

Waste caustics originate from the caustic washing of light oils to remove mercaptans, hydrogen sulfide, and other acidic materials that occur naturally in crude oil or any of its fractions or may be produced by a variety of processing methods.

The constituents of waste caustics responsible for their potent pollution characteristics include mercaptans, thiophenol, thiocresols, phenols, cresols, disulfides, alkylsulfides, the sodium salts of any one of a number of saturated mono acids, naphthenic acids or sulfonic acids and other materials.

II.A.1.h. Alkaline Waters

Alkaline waters, as differentiated from alkaline condensate waters and waste caustics, may originate from the washings of neutralized acid treated oils, the washings of caustic treated oils, the dehydration of treated light oils, the aqueous tank bottoms of stored caustic treated and washed gasolines, vessel and tower washings at times of shutdowns and miscellaneous sources.

II.A.1.i. Special Chemicals

This category of wastes includes the special solvents and extraction solutions utilized in selective solvent refining, gas purification, light oil treating, etc. Such special chemicals utilized in petroleum processing may include phenol, creosols, furfural, salts of isobutyric acid, nitrobenzene, acetone, methyl ethyl ketone, B.B. dichlorethyl ether, ethylene dichloride, benzol, tannin, fatty acids, diethanol amine, methanol, toluol sodium hypochlorite, tri-sodium phosphate, lead sulfide, copper chloride and others. These special chemicals may create serious waste control problems. The water soluble organics, for example, can add tremendously to the oxygen demand characteristics of the plant wastes if allowed to discharge into the sewers. Others listed are emulsifying agents and would adversely affect separator operation if allowed to mix with other refinery wastes. Frequently, the value of these materials is sufficient to justify the use of collection and recovery systems. Drainage from leaks, spills, pumps, valves, sampling, routine maintenance activities, etc., often is recovered to keep losses to a minimum.

II.A.2. Sources and Quantities of Process-Related Wastes

The permit applicant should identify all sources of process wastes, preferably by means of a schematic or flow diagram. The checklist that follows indicates the major process operations and the associated wastewater streams that should receive a careful, systematic analysis in the EID.

- Crude Desalting
  - Desalter wastewater
- Crude Oil Fractionation
  - Wastewater from overhead accumulators
  - Oil sampling lines
  - Barometric condensers
- Cracking
  - Overhead accumulator wastewater (thermal cracking)
  - Wastewaters from steam strippers and overhead accumulators on fractionators (catalytic)
- Hydrocarbon Rearranging
  - Wastewater from polymerization process
  - Alkylation wastewater streams resulting from the neutralization of hydrocarbon streams leaving the sulfuric acid alkylation reactor
  - Wastewater from overhead accumulator
  - Wastewaters from hydrofluoric acid alkylation rerun-unit
- Hydrocarbon Rearrangements
  - Wastewater from overhead accumulator
- Solvent Refining
  - Fractionation tower bottoms
- Hydrotreating
  - Wastewater from hydrotreatment unit
- Grease Manufacturing
  - Wastewater from grease manufacturing unit
- Asphalt Production
  - Wastewater from asphalt-blowing operations
- Product Finishing
  - Wastewater from drying and sweetening (H_2S removal) process
  - Lubricating oil finishing wastes (acid-bearing wastes, rinse waters, sludges and discharges resulting from acid treatment of lubricating oils)
  - Wastewaters from blending and finishing operations
  - Washing of railroad tank cars or tankers prior to loading
  - Tetraethyl and tetramethyl lead additives. These anti-knock compounds are extremely toxic and can gain entrance to wastewaters via two avenues: (1) TEL and TML are separated from other compounds by a steam distillation and purification process. Water is then contaminated by the condensing steam; (2) TEL and TML are present in tank bottom sludges and contaminate waters through washings and other maintenance.
- Auxiliary Activities
  - Process wastes from hydrogen manufacture
  - Utilities functions (steam and cooling water systems)
  - Blowdowns from closed-loop recirculating systems
  - Sour water stripper
  - General housekeeping

Table 11 presents a qualitative matrix showing the relative contributions of pollutants from various refinery operations.

The estimated wastewater pollutant loadings and volumes per unit for the major refinery processes are present in Table 12. Also the table makes a distinction between process technologies (old, typical, new) and the waste loads that can be expected from each.

II.A.3. Sources and Quantities of Wastewater from Transportation Activities

One of the most unpredictable sources of wastewaters from oil refineries are those associated with the transportation of feedstock and product to and from refineries. Although some of the discharges are associated with the accidental spillage from transport lines, tanker and truck washings, the major concern is associated with tanker and truck accidents and the spillage from a major tanker breakup.

The applicant must consider several key factors to predict the occurrence of and impact from tanker accidents. These include:

- Characteristics of the waterways to and from the unloading location (e.g., narrow passageways with frequent fog and inclement weather conditions, high tides and severe wave action will necessarily have a higher incidence of accidents)
- Nature of the navigational controls and guides available in harbors and passages
- The sophistication and availability of cleanup equipment
- Environmental sensitivity and value of ecosystems within the transport corridor
- Historical record of occurrences of tanker accidents under similar conditions

To assess adequately the potential impacts from an accidental oil spill, one approach could be to develop and evaluate a range of scenarios involving potential tanker accidents of various magnitudes in high probability areas. From this, a projection of ecological consequences could be made for purposes of inclusion in the EID. Table 13 presents a generalized summary of the types and magnitude of tanker accidents throughout the world. It gives an indication of the types and sizes of accidents that historically have been most frequent and significant.

II.B. PROCESS WASTES (AIR EMISSIONS)

Sources of air emissions and air pollutants differ considerably among refineries which largely is a function of:

- Size of refinery
- Type of crude oil feedstock
- Product mix (which dictates the type and complexity of processes employed)
- Pollution control measures

Because of the wide variations possible in the above factors, new refineries

Table 11. Qualitative evaluation of wastewater flow and characteristics by fundamental refinery processes.

Fundamental Processes	Flow	BOD	COD	Phenol	Sulfide	Oil	Emulsified Oil	pH	Temp.	Ammonia	Chlorides	Acidity	Alkalinity	Susp. Solids
Crude Oil and Product Storage	XX	X	XXX	--	--	XXX	XX	0	0	0		0		XX
Crude Oil Desalting	XX	XX	XX	X	XXX	X	XXX	X	XXX	XX	XXX	0	X	XXX
Crude Oil Distillation	XXX	X	X	XX	XXX	XX	XXX	X	XX	XXX	X	0	X	X
Thermal Cracking	X	X	X	X	X	X	--	XX	XX	X	X	0	XX	X
Catalytic Cracking	XXX	XX	XX	XXX	XXX	X	X	XXX	XX	XXX	X	0	XXX	X
Hydrocracking	X	--	--	--	XX	--	--	--	XX	--	--	--	--	--
Reforming	X	0	0	X	X	X	0	0	X	X	0	0	0	0
Polymerization	X	X	X	0	X	X	0	X	X	X	X	X	0	X
Alkylation	XX	X	X	0	XX	X	0	XX	X	X	XX	XX	0	XX
Isomerization	X	--	--	--	--	--	--	--	--	--	--	--	--	--
Solvent Refining	X	--	X	X	0	--	X	X	0	--		0	X	
Dewaxing	X	XXX	XXX	X	0	X	0	--	--	--	--	--	--	--
Hydrotreating	X	X	X	--	XX		0	XX	--	0	0	0	X	0
Drying and Sweetening	XXX	XXX	X	XX	0	0	X	XX	0	X	0	X	X	XX

Legend

XXX - Major contribution
XX - Moderate contribution
X - Minor contribution
0 - No Problem
-- - No data

Source: US-DOI. 1967. The cost of clean water. Volume III, Industrial Waste Profile No. 5: Petroleum Refining. FWPCA Publication No. I.W.P.-5. Available from US-GPO. Washington, DC.

Table 12. Estimated waste loadings and volumes per unit of fundamental process throughput for older, typical, and newer process technologies

	Older Technology				Typical Technology				Newer Technology			
Fundamental Process	Flow (gal/bbl)	BOD (lb/bbl)	Phenol (lb/bbl)	Mercaptans &Sulfides (lb/bbl)	Flow (gal/bbl)	BOD (lb/bbl)	Phenol (lb/bbl)	Mercaptans &Sulfides (lb/bbl)	Flow (gal/bbl)	BOD (lb/bbl)	Phenol (lb/bbl)	Mercaptans &Sulfides (lb/bbl)
Crude Oil and Product Storage	4	0.001	-	-	4	0.001	-	-	4	0.001	-	-
Crude Desalting	2	0.002	0.20	0.002	2	0.002	0.10	0.002	2	0.002	0.05	0.002
Crude Fractionation	100	0.020	3.0	0.001	50	0.0002	1.0	0.001	10	0.0002	1.0	0.001
Thermal Cracking	66	0.001	7.0	0.002	2	0.001	0.2	0.001	1.5	0.001	0.2	0.001
Catalytic Cracking	85	0.062	50.0	0.03	30	0.010	20	0.003	5	0.010	5	0.003
Hydrocracking	not in this technology				not in this technology				5	-	-	-
Reforming	9	tr	0.7	tr	6	tr	0.7	0.001	6	tr	0.7	0.001
Polymerization	300	0.003	1.4	0.22	140	0.003	0.4	0.010	not in this technology			
Alkylation	173	0.001	0.1	0.005	60	0.001	0.1	0.010	20	0.001	0.1	0.020
Isomerization	not in this technology				not in this technology				-	-	-	-
Solvent Refining	8	-	3	tr	8	-	3	tr	8	-	3	tr
Dewaxing	247	0.52	2	tr	23	0.50	1.5	tr	20	0.25	1.5	tr
Hydrotreating	1	0.002	0.6	0.007	1	0.002	0.01	0.002	8	0.002	0.01	0.002
Deasphalting	-	-	-	-	-	-	-	-	-	-	-	-
Drying and Sweetening	100	0.10	10	-	40	0.05	10	-	40	0.05	10	-
Wax Finishing	-	-	-	-	-	-	-	-	-	-	-	-
Grease Manufacture	-	-	-	-	-	-	-	-	-	-	-	-
Lube Oil Finishing	-	-	-	-	-	-	-	-	-	-	-	-
Hydrogen Manufacture	not in this technology				not in this technology				-	-	-	-
Blending and Packaging	-	-	-	-	-	-	-		-	-	-	-

- Data not available for reasonable estimate.
tr = trace

Source: US-DOI. 1967. The cost of clean water. Volume III, Industrial Waste Profile No. 5: Petroleum Refining. FWPCA Publication No. I.W.P.-5. Available from US-GPO, Washington, DC.

Table 13. Types and magnitude of tanker casualties worldwide.

Type of Casualty	Percent of Polluting Incidents	Percent of Pollution Resulting
Structural Failures	19	49
Groundings	26	29
Collisions	31	8
Explosions	6	8
Rammings	8	1
Fires	7	1
Breakdowns and Other	3	4

Range-Barrels	Percent of Incidents	Percent of Total Oil Released
1 to 1,000	[illegible]	5.75
1,001 to 3,500	[illegible]	11.29
3,501 to 20,000	[illegible]	16.07
20,001 to 100,000	[illegible]	37.74
> 100,000	[illegible]	29.15

Source: US-EPA. 1975. Environmental impact assessment guidelines for selected new source industries. Office of Federal Activities, Washington, DC.

normally must be assessed on an individual basis. There are, however, certain types of emissions which must be addressed in an emission assessment of any refinery, and there are certain major sources of emissions which must be evaluated if they are part of the refinery's process scheme.

Specifically the EID should identify, describe (quantitatively), and evaluate all such refinery air emissions. Interim heat releases, start-up, shut-down, safety valve releases, leaks and any other potential sources of emissions should be documented in the EID. Major sources of air waste streams from a petroleum refinery include:

- Storage tanks
- Catalyst regeneration units
- Pipeline valves and flanges
- Pressure relief valves
- Pumps and compressors
- Compressor engines
- Acid treating
- Wastewater separators and process drains
- Cooling towers
- Loading facilities
- Blowdown systems
- Pipeline blind-flange changing
- Boilers and process heaters
- Vacuum jets
- Sampling
- Air blowing

The waste gases from petroleum refining are stack gases from furnaces and reactors, hydrogen sulfide and sulfur dioxide. Except that stack gases may be used in waste treatment processes or may be scrubbed with water for solids removal they do not enter into water pollution control problems.

The acid gases (hydrogen sulfide and sulfur dioxide), however, may cause water pollution control problems. Hydrogen sulfide as produced from the distillation of crude and other processing is a contaminant to other refinery gases (i.e., methane, ethane, etc.). The removal of hydrogen sulfide from liquid and gaseous hydrocarbon stream creates wastewaters of highly obnoxious characteristics. These wastes were discussed briefy in section I.E.3.

Sulfur dioxide is produced from stack gases, sulfuric acid concentrators, liquid sulfur dioxide refining units and sulfuric acid treating units. Normally sulfur dioxide wastes are discharged to the atmosphere. However, not infrequently atmospheric pollution problems must be corrected and the corrective measures may create water pollution problems. The utlization of sulfur dioxide for the recovery of sulfur offers the best long term solution to the problem of pollution abatement. In addition to the formation of SO_2 during the combustion of sulfur-containing liquid refinery fuels, NOx formation can be enhanced if those fuels also contain nitrogen compounds. This NOx, as well as the small amount of SO_3 formed from sulfur compounds in the fuel, tend to be the principal cause of stack plumes from refinery furnaces.

Carbon monoxide and particulate emissions also occur, however, they largely are confined to flue gases from catalytic crack regenerators and fluid cokers (unless coal or coke are used as fuel).

The principal types of air pollutants from various emission sources are shown in Table 14.

II.C. PROCESS WASTES (SOLID WASTES)

Typical solid wastes generated at a refinery include process sludges, spent catalysts, and various sediments. The applicant should identify all solid waste streams and provide a flow diagram which quantitatively and qualitatively describes their characteristics.

Refinery solid wastes are grouped into three general categories:

- Process solids
- Effluent treatment solids
- General wastes (scrap materials, etc.)

Tank bottom sludges vary greatly in their characteristics, e.g., from an easily pumpable fluid to a set solid. In general these wastes may be treated for oil recovery or burned as fuel. Sometimes for the purpose of tank cleaning it is advantageous to flush these materials from the tanks using water. In some cases water flushing will create emulsions and suspensions that will produce unsatisfactory waste water effluents. The use of water flushing should be avoided as much as possible.

One of the major sources of sludge of high pollutional characteristics is the acid treatment of refinery stocks (See Section I.E.3. Acid Wastes).

Sludge accumulating at the bottom of cooling towers generally is adaptable to disposal as fill. However, the removal of the sludge from the tower basin and the transfer of the material to the point of final disposal can pose numerous problems in cleaning, transportation and storage.

Sludge from the clarification of water for process use create the same type of problem as that of cooling tower sludge.

Sludge from the softening of water may be utilized, in some cases, for the neutralization of acid waters or as a coagulant aide in wastewater treatment.

Table 15 presents sources, descriptions, and characteristics of various categories of solid wastes generated from refinery operations. Table 16 lists the range of factors that can affect the composition and quantity of solid waste streams. Such factors should be considered by a new source applicant in designing control measures for solid waste generation and disposal.

Many solids may contain significant amounts of leachable heavy metals and organics which could contaminate the environment if not treated and disposed of properly. Therefore, to evaluate the potential impacts from solid wastes,

Table 14. Major air pollutants emitted from various refinery sources.

Pollutant	
Oxides of Sulfur	Boilers, process heaters, catalytic cracking unit regenerators, treating units, H_2S flares, decoking operations
Hydrocarbons	Loading facilities, turnarounds, sampling, storage tanks, wastewater separators, blow-down systems, catalyst regenerators, pumps, valves, blind changing, cooling towers, vacuum jets, barometric condensers, air-blowing, high pressure equipment handling volatile hydrocarbons, process heaters, boilers, compressor engines
Oxides of Nitrogen	Process heaters, boilers, compressor engines, catalyst regenerators, flares
Particulate Matter	Catalyst regenerators, boilers, process heaters, decoking operations, incinerators
Aldehydes	Catalyst regenerators
Ammonia	Catalyst regenerators
Odors	Treating units (air-blowing, steam-blowing), drains, tanks vents, barometric condenser sumps, wastewater separators
Carbon Monoxide	Catalyst regeneration, decoking, compressor engines, incinerators

Source: US-DHEW. 1960. Atmospheric emissions from petroleum refineries. Public Health Service Publication No. 763, Washington, DC.

Table 15. Categorization of representative solid wastes from various petroleum refining sources.

Waste Category	Waste Sources	Waste Description	Waste Characteristic
Process Solids	Crude oil storage, desalter	Basic sediment and water	Iron rust, iron sulfides, clay, sand, water oil
	Catalytic cracking	Catalyst fines	Inert solids, catalyst particles, carbon
	Coker	Coker fines	Carbon particles, hydrocarbons
	Alkylation	Spent sludges	Calcium flouride, bauxite, aluminum chloride
	Lube oil treatment	Spent clay sludges, press dumps	Clay, acid sludges, oil
	Drying and sweetening	Copper sweetening residues	Copper compounds, sulfides, hydrocarbons
	Storage tanks	Tank bottoms (crude, leaded, non-leaded)	Oil, water, solids
	Slop oil treatment	Precoat vacuum filter sludges	Oil, diatomaceous earth, solids
Effluent Treatment Solids	API separator	Separator sludge	Oil, sand and various process solids
	Chemical treatment	Flocculant aided precipitates	Aluminum or ferric hydroxides, calcium carbonate
	Air flotation	Scums or froth	Oil, solids, flocculants(if used)
	Biological treatment	Waste sludges	Water, biological solids, inerts
General Waste	Water treatment plant	Water treatment sludges	Calcium carbonate, alumina, ferric oxide, silica
	Office	Waste paper	Paper, cardboard
	Cafeteria	Food wastes (garbage)	Putrescible matter, paper
	Shipping and receiving	Packaging materials, strapping pallets, cartons, returned products, cans, drums	Paper, wood, some metal, wire
	Boiler plant	Ashes, dust	Inert solids
	Laboratory	Used samples, bottles, cans	Glass, metals, waste products
	Plant expansion	Construction and demolition	Dirt, building materials, insulation, scrap metal
	Maintenance	General refuse	Insulation, dirt, scrapped materials-valves, hoses, pipe

Source: US-EPA. 1975. Environmental impact assessment guidelines for selected new source industries. Office of Federal Activities, Washington, DC.

Table 16. Factors affecting the composition and quantity of specific solid waste streams.

Solid Waste	Potential Factors
Crude tank bottoms	Type of crude
	Treatment given to crude prior to storage
	Slop oil processing method
	Refinery size
	Mixing, if any
	Storage time
	Degree, if any, of sludge emulsion breaking
Leaded tank bottoms	Type and quantity of chemical additives
	Plant and tank metallurgy
	Type of product treatment used
	Type of processes used in producing gasoline and/or other products
	Refinery size
Non-leaded tank bottoms	Type and quantity of chemical additives
	Plant and tank metallurgy
	Type of product treatment used
	Type of processes used in producing gasoline and/or other products
	Refinery size
API separator sludge	Composition and quantity of process wastewater
	Composition and quantity of spills and leaks
	Composition and quantities blowdowns
	Refinery housekeeping
	Refinery size and age
	Segregation of refinery sewers
Neutralized HF alkylation sludge	Composition of fresh hydrofluoric (HF) acid
	Composition of lime
	Feedstock composition
	Process operating conditions
	Hydrofluoric acid alkylation process metallury
	Size of hydrofluoric acid
Spent filter clays	Type and number of clay treatment processes used
	Type and number of products treated
	Composition and quantity of products treated
	Type and amount of clay used
	Refinery size
Once-through cooling water sludge	Composition and quantity of raw water
	Cooling system metallurgy
	Size and nature of process leaks
	Refinery size and complexity

Table 16. Factors affecting the composition and quantity of specific solid waste streams (Continued).

Solid Waste	Potential Factors
DAF float	Same factors as API separator sludge plus: Residence time Amount and time of flocculating chemical used Efficiency of API separator
Slop oil emulsions solids	Composition and quantity of individual oil spills and oil leakage Composition of wastewater emulsions Nature of emulsion breaking treatment and degree of success Refinery size and complexity Quantity of oil in wastewater and degree of removal
Spent lime from boiler feedwater treatment	Composition of raw water Degree of hardness removed Type of treatment (hot or cold) Refinery size Boiler blowdown rates Percent condensate recovered and returned to boilers
Cooling tower sludge	Make-up water composition Type of chemical treatments employed Metallurgy of cooling water system Nature of contaminants introduced by process leaks Blowdown rate Make-up water rate Quantity of treatment chemicals used
Exchanger bundle cleaning sludge	Composition of shell and tubeside fluids Equipment metallurgy Effectiveness of desalter Refinery size and complexity Effectiveness of corrosion inhibitor systems
Waste bio-sludge	Composition and quantity of wastewater treated Type of biological treatment Efficiency of prior treatment units Operating conditions and practice Dewatering and/or treatment
Stormwater silt	Plant housekeeping Amount of rain Amount of refinery area paved Segregation of surface drainage

Table 16. Factors affecting the composition and quantity of specific solid waste streams (Concluded).

Solid Waste	Potential Factors
FCC catalyst fines	Catalyst compositon
	Oil composition
	Type of process
	Process operating conditions (temperature, percent conversion, recycle feed rate)
	Catalyst make-up rate
	Process metallurgy
	Oil feed rate
	Number of cyclones
	Use of precipitators
	Use of elutriators
Coke fines	Oil composition
	Type of process
	Operating condition (temperature, pressure, time)
	Process metallurgy
	Method of coke removal
	Method of handling and shipping
	Number of cyclone stages
	Oil feed rate

Source: US-EPA. 1976. Assessment of hazardous waste practices in the petroleum refining industry. Prepared by Jacobs Engineering Company. NTIS Publication PB-259 097, Washington, DC.

the applicant should provide at least the following information in the EJD:

- Source and quantity of solid wastes generated
- Chemical composition of solid wastes generated
- Composition of possible hazardous leachates from solid wastes (quantitative)
- Proposed measures to handle and dispose of solid wastes and the ecological sensitivity of all proposed deposition areas

Table 17 lists typical refinery pollutants by source. Pollutants are listed in terms of 1,000 barrels of crude oil processed. Total emissions and effluents quantities can be approximated (although often the existing data base was unsuitable for projecting certain pollutant levels).

II.D. TOXICITY AND POTENTIAL FOR ENVIRONMENTAL DAMAGE FROM SELECTED POLLUTANTS

II.D.1. Human Health Impacts

Airborne and waterborne emissions from petroleum refineries may contain substances which could seriously affect human health. Both heavy metals and a variety of complex hydrocarbons are emitted from refinery operations. Petroleum-related contamination of ground water drinking supplies is another serious problem. The following paragraphs describe briefly the major health-related effects of selected pollutants.

II.D.1.a. Carcinogens

During various refinery operations a worker may be exposed to such suspected carcinogens as arsenic, benzene, cadmium, chromium, cobalt, lead, vanadium, and certain organics. Likewise these carcinogens may pose a threat to those in the plant vicinity. These and other trace metals along with their potential health problems are presented in Table 18; references to detailed research studies are provided.

II.D.1.b. Sulfur Dioxide, Hydrogen Sulfide, and Mercaptans

The impact of high concentrations of sulfur dioxide and sulfates (especially in the presence of particulates), has been well documented (USEPA 1970). Normally emissions of sulfur dioxide from petroleum refineries would not produce concentrations that would exceed national ambient air quality standards. However, even SO_2 levels below national ambient air quality standards may produce some adverse impacts upon sensitive receptors. The formation of sulfates at very low concentrations of sulfur dioxide may produce significant eye and respiratory problems (Science Applications, Inc. 1975) as well as damage to vegetation and to certain materials (metal surfaces).

Likewise hydrogen sulfide and other reduced sulfur compounds (i.e., mercaptans) is strongly irritating to the respiratory organs. At high concentrations (1,000 mg/m^3), hydrogen sulfide is extremely toxic and may paralyze the brain center that controls respiratory movements (Cavanaugh 1975).

Table 17. Summary of pollutant sources and projected pollutant concentrations.

Source of Pollutant	BOD	COD	Particulates	NOx	SOx	Hydrocarbons	Solids
	Pollutant Levels kg/1000 bbl.(lbs./1000 bbl.).						
Transport							
Crude or product	-	-	-	-	-	-	-
Pipeline	-	-	.86(1.9)	24.94(55)	1.81(40)	2.50(5.5)	-
Tankers	-	-	.18(04)	17.27(38)	2.63(5.8)	.09(0.2)	-
Supertankers	-	-	.19(.042)	17.27(38)	2.63(5.8)	.09(0.2)	-
Barges	-	-	15.42(34)	10.90(24)	11.79(26)	7.26(16)	-
Tank Trucks	-	-	3.17(7)	95.26(210)	6.80(15)	9.53(21)	-
Tank Cars	-	-	6.35(14)	19.50(43)	16.78(37)	13.15(29)	-
Processing							
Crude desalting	.45	-	0(0)	0(0)	0(0)	0(0)	0(0)
Crude fractionation	.09(0.2)	2.27(5)	1.04(2.3)	12.25(27)	.045(0.1)	15.42(34)	-
Cracking	6.8(15)	8.16(18)	7.71(17)	46.27(102)	136.08(300)	19.96(44)	21.77(48)
Hydrocarbon rebuilding	5.4(12)	64.41(142)	3.17(7)	50.80(112)	.045(0.1)	34.92(Ti)	-
Hydrocarbon rearrangement	-	18.14(40)	2.27(5)	65.32(144)	.023(0.05)	15.72(34)	-
Solvent refining	-	-	-	-	-	40.82(90)	-
Hydrotreating	43.1(95)	45.36(100)	2.27(5)	22.68(50)	-	54.43(120)	-
Grease manufacturing	-	-	-	-	-	10.43(23)	-
Asphalt production	-	14.51(32)	2.72(6)	31.75(70)	.090(0.2)	15.88(35)	-
Storage							
Crude	.45(1)	-	0	0	0	28.12(62)	-
Product	-	-	-	-	-	9.53(21)	-

Source: US-EPA. 1974. Environmental impacts, efficiency and cost of energy supply and end use. Volume 1 Final Report. Prepared by Hittman Associates, Washington, DC.

Table 18. Possible health problems associated with trace metals

Metal or metal compounds	Health problems	Reference
Aluminum, arsenic, cadmium, cobalt, copper, iron, lead, and zinc oxides	Enzymatic inference Fume fever	(Waldbott 1973)
Nickel	Nasal cancers	(Potts 1965) (Gilman and Ruckerbauer 1963)
Cadmium	Prostate cancer Enzymatic interference	(Potts 1965) (Kipling and Waterhouse 1967)
Chromium and compounds	Carcinogenesis	(Hueper 1961)
Arsenic	Cancer of the skin Poisoning	(Wickstrom 1972) (Lee and Fraumeni 1969)
Cobalt	Carcinogenesis	(Gilman and Ruckerbauer 1963)
Lead and compounds	Nasal cancers	(Zawirsica and Medras 1968)
	Kidney damage	(Zollinger 1953)
Mercury and compounds	Mutagenic and teratogenic effects	(D'Itri 1972)
Vanadium	Inhibition of lipid formation; eye and respiratory irritant; carcinogenic	(Stokinger 1963)
Zinc	Gastrointestinal irritation	(Waldbott 1973)

II.D.1.c. Nitrogen Compounds

Nitrogen oxides are pulmonary irritants and may impair the ability of the lungs to clear inhaled infectious organisms. Exposure to nitrogen dioxide also can be corrosive to the mucous lining of the lungs. At high concentrations, it may cause pulmonary edema and even death, while chronic exposure may produce emphysema, polyeythamia, and leukocytosis. Further, nitrogen oxides have been shown to contribute to the formation of photochemical smog (USEPA 1971c).

II.D.1.d. Hydrocarbons

Apart from their potential carcinogenic activity, hydrocarbons play a vital role in the formation of photochemical smog (USEPA 1971b).

II.B.1.e. Carbon Monoxide

The toxicity of carbon monoxide is associated with its reactions with hemoproteins. Generally one can anticipate that there will be no increase of ambient concentrations of CO beyond national ambient air standards as a result of refinery emissions.

II.D.1.f. Ammonia

Ammonia is a highly irritating gas with a strong, pungent odor. It forms ammonium hydroxide when it comes in contact with the moisture of the throat and bronchi. Ammonium hydroxide is caustic, but it is not usually considered a threat to human health. Extremely high concentrations, however, (1,700-4,500 mg/m^3) can produce pulmonary edema (Waldbott 1973).

II.D.1.g. Trace Metals

Among the possible health problems associated with trace metals are those shown in Table 18. The appropriate references should be reviewed by the permit applicant to ascertain the significance of the impact as associated with trace metal emissions from the proposed petroleum refining facility.

To adequately evaluate potential impacts to human health, the applicant should include at least the following information in the EID:

- Analysis of metal-containing catalysts used in the refining process
- Analysis of crude oil to be used in the refining process
- Projection of emissions of potentially toxic substances (volumes, frequencies, and duration)
- Analysis of sensitive receptors (by use of isopleths or other suitable technique)
- Groundwater parameters including depth to water, direction of flow, interflow between ground and surface waters, stratigraphy to aquifer local groundwater withdrawals
- Projection of ground level maximum concentrations of potentially hazardous substances
- Description of proposed measures to avoid or reduce potential adverse effects from toxic materials

II.D.2. Biological Impacts

The biological environment also may be affected by certain pollutants especially heavy metals and certain chlorinated and cydic hydrocarbons which are toxic to many terrestrial and aquatic organisms.

The potential impacts on terrestrial and aquatic biota may be categorized by the following waste streams and pollutants:

- Air pollutants - emissions of heavy metals, sulfur compounds, particulates, and hydrocarbons
- Wastewater discharges - water pollutants such as heavy metals and toxic organics from process wastes, leachate from solid waste residues.
- Solid wastes - stockpiling and disposal of process sludges and other solid wastes (spent catalysts, sediments)

At a minimum the following factors should be described in the EID to assess adequately the extent and significance of impacts to biological resources:

- Discharges and sinks for specific toxic materials such as heavy metals and organics, including information on conventional and priority (consent decree) chemicals, volume, duration, and time of discharges)
- Characteristics of the aquatic and terrestrial biota of the impact area (species composition, diversity, abundance, densities, importance values)
- Description of economic, aesthetic, recreational and other uses or potential uses of the aquatic and terrestrial receiving environments
- Complete characterization of the aquatic land and air environments that are to receive waste discharges
- Determination of tolerance or sensitivity thresholds for selected species of plants and animals in the impact area
- Proposed measures to avoid or reduce adverse impacts to biological communities

II.E. OTHER IMPACTS

II.E.1. Raw Materials Extraction and Transportation

EPA requires that the environmental impacts of all activities directly caused or induced by a new source industry be assessed. A new petroleum refinery may cause changes in the level and nature of activities for extraction, transportation and handling of crude oil raw materials and various metals such as platinum which are used as catalysts. If such changes occur, their environmental impacts must be assessed in the EID. EPA's Regional responsible official is the arbiter of whether or not a particular activity is directly caused or induced by the new source facility. The proposed refinery complex also may include integral support or ancillary facilities as deepwater ports, submerged pipelines, marine terminals, overland pipelines, bulk storage areas, and loading areas.

As appropriate, such facilities should be fully described and analyzed in the EID.

By way of guidance, the degree of detail given to impact evaluations for these facilities could be directly proportional to the degree to which such facilities are directly owned, operated, or supported by the proposed refinery. In cases where the proposed refinery will construct its own marine facility, or deepwater port, for example, the impact investigation would be tantamount to that for the refinery itself. This would apply to cases where a substantial part of the deepwater port or marine facility would be leased to other industry. If, however, the port facilities are being expanded to meet the new refinery demands by some independent or non-affiliated party, the degree of detail might be different. In short, the permit applicant should consult with EPA officials as to the required information and detail.

II.E.2. Site Preparation and Refinery Construction

The environmental effects of site preparation and construction of new oil refinery facilities are common to most major land disturbing activities. Although erosion, dust, noise, vehicular traffic and emissions, and some loss of wildlife habitats are expected, the applicant has a number of mitigative measures available by which adverse impacts can be reduced. At present, however, neither the quantities of the various pollutants resulting from site preparation and construction nor their effects on the integrity of aquatic and terrestrial ecosystems has been studied sufficiently to permit broad generalizations. Therefore in addition to the impact assessment framework provided in the EPA document, Environmental Impact Assessment Guidelines for Selected New Source Industries, a suggested checklist of important study items is presented in Table 19 for further guidance to the applicant. The basic components of site preparation and plant construction outlined in the table include preconstruction, site work, permanent facilities, and ancillary facilities. At this time only potentially significant areas of impact are presented in the checklist, but a system of importance values should be assigned to the checklist items after sufficient quantitative data have been acquired at an individual site or for a region. The permit applicant also should tailor all proposed conservation practices to the specific site(s) being considered in order to account for and to protect certain site-specific features that warrant special attention (e.g., critical habitats of imperiled species, archaeological/historical sites, high quality streams, wetlands, or other sensitive areas on the site). All mitigating conservation measures which are proposed to avoid or reduce adverse impacts from preparation of the site and construction activities should be described in the EID.

II.F. MODELING OF IMPACTS

The ability to forecast environmental impacts accurately often is improved by the use of mathematical modeling of the dispersion and dissipation of air and water pollutants as well as the effects of storm runoff.

Two of the most widely used and accepted models are:

- DOSAG (and its modifications)
- The QUAL series of models developed by the Texas Water Development Board and modified by Water Resources Engineers, Inc.

Table 19. Outline of potential environmental impacts and relevant pollutants resulting from site preparation and construction practices.

Construction practice	Potential environmental impacts	Primary pollutants
1. Preconstruction		
a. Site inventory	Short term and nominal	Dust, noise, sediment
(1) Vehicular traffic	Dust, sediment, tree injury	
(2) Test pits	Tree root injury, sediment	
b. Environmental monitoring	Negligible if properly done	Visual
c. Temporary controls	Short term and nominal	Sediment spoil, nutrients, solid waste
(1) Sedimentation ponds	Vegetation destroyed, water quality improved	
(2) Dikes and berms	Vegetation destroyed, water quality improved	
(3) Vegetation	Fertilizers in excess	
(4) Dust control	Negligible if properly done	
2. Site Work		
a. Clearing and demolition	Short term	Dust, sediment, noise solid wastes, wood wastes
(1) Clearing	Decreased area of protective tree, shrub, ground covers; stripping of topsoil; increased soil erosion, sedimentation, stormwater runoff; increased stream water temperatures; modification of stream banks and channels, water quality	
(2) Demolition	Increased dust, noise, solid wastes	
b. Temporary facilities	Long term	Gases, odors, fumes particulates, dust, deicing chemicals, noise, petroleum products, wastewater, solid wastes, aerosols, pesticides
(1) Shops and storage sheds	Increased surface areas impervious to water infiltration, increased water runoff, petroleum products	
(2) Access roads and parking lots	Increased surface areas impervious to water infiltration, increased water runoff, generation of dust on unpaved areas	

(continued on next page)

Table 19. Outline of potential environmental impacts and relevant pollutants resulting from site preparation and construction practices (Continued).

Construction practice	Potential environmental impacts	Primary pollutants
(3) Utility trenches and backfills	Increased visual impacts, soil erosion, sedimentation for short periods	
(4) Sanitary facilities	Increased visual impacts, solid wastes	
(5) Fences	Barriers to animal migration	
(6) Laydown areas	Visual impacts, increased runoff	
(7) Concrete batch plant	Increased visual impacts; disposal of wastewater, increased dust and noise	
(8) Temporary and permanent pest control (termites, weeds, insects)	Nondegradable or slowly degradable pesticides are accumulated by plants and animals, then passed up the food chain to man. Degradable pesticides having short biological half-lives are preferred for use	
c. Earthwork	Long term	Dust, noise, sediment, debris, wood wastes, solid wastes, pesticides, particulates, bituminous products, soil conditioner chemicals
(1) Excavation (2) Grading (3) Trenching (4) Soil treatment	Stripping, soil stockpiling, and site grading; increased erosion, sedimentation, and runoff; soil compaction; increased in-soil levels of potentially hazardous materials; side effects on living plants and animals, and the incorporation of decomposition products into food chains, water quality	
d. Site drainage	Long term	Sediment
(1) Foundation drainage (2) Dewatering (3) Well points (4) Stream channel relocation	Decreased volume of underground water for short and long time periods, increased stream flow volumes and velocities, downstream damages, water quality	
e. Landscaping		Nutrients, pesticides
(1) Temporary seeding (2) Permanent seeding and sodding	Decreased soil erosion and overland flow of stormwater, stabilization of exposed cut and fill slopes, increased water infiltration and underground storage of water, minimized visual impacts	

(continued on next page)

Table 19. Outline of potential environmental impacts and relevant pollutants resulting from site preparation and construction practices (Continued).

Construction practice	Potential environmental impacts	Primary pollutants
3. Permanent facilities		
a. Petroleum refinery and heavy traffic areas	Long term	Sediment, dust, noise, particulates
(1) Parking lots	Stormwater runoff, petroluem products	
(2) Marine terminal	Visual impacts, sediment, runoff	
b. Other buildings	Long term	Solid wastes
(1) Warehouses	Impervious surfaces, stormwater runoff, solid wastes, spillages	
(2) Sanitary waste treatment	Odors, discharges, bacteria, viruses	
c. Possible ancillary facilities	Long term	Sediment, trace elements, noise, caustic chemical wastes, spoil, flocculants, particulates, fumes, solid wastes, nutrients.
(1) Intake and discharge channel	Shoreline changes, bottom topography changes, fish migration, benthic fauna changes	
(2) Water supply and treatment	Waste discharges, water quality	
(3) Stormwater drainage	Sediment, water quality	
(4) Wastewater treatment	Sediment, water quality	
(5) Dams and impoundments	Dredging, shoreline erosion	
(6) Breakwaters, jetties, etc.	Circulation patterns in the waterway	
(7) Fuel handling equipment	Spillages, fire, and visual impacts	
(8) Waste storage areas	Visual impacts, waste discharges	
(9) Overland or underground pipelines, bulk storage areas, loading areas	Sediment runoff and erosion, landscape alteration, waste discharges, visual impacts	
(10) Conveying systems (cranes, hoists, chutes)	Visual impacts	
(11) Cooling lakes and ponds	Conversion of terrestrial and free flowing stream environment to a lake environmenta(land use trade-offs); hydrological changes, habitat changes, sedimentation, water quality	

(continued on next page)

Table 19. Outline of potential environmental impacts and relevant pollutants resulting from site preparation and construction practices (Concluded).

Construction practice	Potential environmental impacts	Primary pollutants
(12) Solid waste handling equipment (incinerators, trash compactors)	Noise, visual impacts	Particulates, dust, solid wastes
d. Security fencing	Long term	Sediments, wood wastes
(1) Access road	Increased runoff	
(2) Fencing	Barriers to animal movements	

Source: Modified from Hittman Associates, Inc. 1974. General environmental guidelines for evaluating and reporting the effects of nuclear power plant site preparation, plant and transmission facility construction. Modified from: Atomic Industrial Forum, Inc. Washington, DC.

Some of the parameters that these models simulate are:

- Dissolved oxygen
- BOD
- Temperature
- pH
- Solids

There also are available mathematical models that may be used for air pollution studies and solid waste management optimization:

- For short term dispersion modeling of point sources, EPA's PTMAX, PTDIS, and PTMTP models may be employed.

- For modeling of long term concentrations over larger areas, the EPA's Climatological Dispersion Model, AQDM and CRSTER, may be used for point and area sources.

In general, the use of mathematical models is indicated when arithmetic calculations are too repetitious or too complex. Their use also simplifies analysis of systems with intricate interaction of variables. Models thus offer a convenient way of describing the behavior of environmental systems, but their use and applicability should be determined on a case by case basis. (For a more detailed discussion of modeling techniques see Section II.E., Modeling of Impacts, in Environmental Impact Assessment Guidelines for New Source Fossil-Fueled Steam Electric Generating Stations, (EPA 13016-79-001).

III. POLLUTION CONTROL

III.A. STANDARDS OF PERFORMANCE TECHNOLOGY: IN-PROCESS CONTROLS - WATER, AIR, SOLID WASTES

There are a number of pollution control measures which can be taken to effectively reduce refinery waste streams and their associated impacts. Many of these steps also will reduce operation and capital costs and/or increase production. The EID should contain a discussion of the applicability of these steps to the particular installation. Discussions of pollution control should consider reduction of effluents and emissions at the source (design planning, etc.). Further, reuse and recycling options should be investigated and may include:

- Use of catalytic cracker accumulator wastewaters rich in H_2S for makeup to crude desalters
- Use of blowdown condensate from high pressure boilers for makeup to low pressure boilers
- Reuse of waters that have been treated for closed cooling systems, fire mains and everyday washing operations
- Stormwater use for routine water applicators
- Blowdown waters from cooling towers for use as water seals on high temperature pumps
- Recirculation of steam condensate
- Recycling of cooling waters

Effective maintenance measures also can reduce waste streams. The applicant should describe all proposed maintenance activities in the EID. They may include:

- Recovery of oil spills and hydrocarbons with vacuum trucks to reduce emission and water effluents
- Reduction of leaks and accidents through preventive maintenance (pump seals, valve stems, etc.)
- Separation of hazardous wastes, concentrated wastes, and other process wastes from general effluents for more effective treatment
- Diking of process unit areas to control and treat spills, oily stormwater runoff, or periodic washes
- Reduction of shock pollution loads on treatment facilities through the periodic flushing of process sewers to prevent contaminant buildup
- Development of a specialized program for handling hazardous wastes, sludges, washwaters and other effluents
- Development of a system to minimize wastes from monitoring stations
- Improvement of personnel awareness that waste treatment is initiated at the process unit.

Actual process changes often can reduce pollution significantly while returning a value through recovery. Technology changes that reduce pollution may not be as cost-effective during process cycles, but may prove to be highly beneficial when waste treatment costs have been reduced. Depending on the feasibility and suitability of a particular project, such process technology changes may include:

- Catalyst switching to a longlife catalyst with greater activity to reduce regeneration frequency
- Replacement of barometric condensers (direct-contact condensers) with surface condensers (indirect-contact condensers) or air-fin coolers

III.A.1. Cooling System

A description of the cooling system is necessary including possible alternatives, i.e., nonevaporative devices. The evaporating cooling systems include spray ponds, mechanical-draft cooling towers, atmospheric cooling towers, and natural-draft cooling towers. Treated wastewater should be considered for makeup purposes. The cooling water blowdown composition is dependent on the composition of the original water used, the operation methods, and cooling water treatment. Chromates, zinc, polyphosphates, dust, other corrosion inhibitors and micro-organisms are constituents of the cooling treatment wastewaters. A discussion of alternate treatment methods, process operations and piping materials also should be discussed. Dry cooling systems of air-fins to dissipate the undesired heat directly to the atmosphere should be discussed.

III.A.2. In-Process Physical/Chemical Pretreatment

The applicant should discuss the following important pretreatment steps in the EID:

- Flow equalization neutralization of spent acid and spent caustic wastewaters
- Oil separators and slop oil recovery systems
- Clarifiers to separate sediments using chemical coagulants as needed
- Sour water stripping

III.B. STANDARDS OF PERFORMANCE TECHNOLOGY: END-OF-PROCESS CONTROL (WATER STREAMS)

Table 6 (page 33) identifies and estimates the various wastewater treatment processes used by petroleum refineries. It illustrates the impact of the recent environmental considerations on the increased usage of wastewater pollution control devices.

Depending on refinery location, refinery plant size, the refining process (degree of crude finishing), and wastewater characteristics, the wastewater treatment facilities are designed based on the processes in Table 6. Table 12 (page 65) shows wastewater characteristics and quantities for the various petroleum unit operation.

The EID should demonstrate that the applicant has given adequate attention to implementation of new technology for abatement of water pollution. The EID should include an understandable, but complete description of the proposed wastewater treatment system. A process flow diagram also should be provided to illustrate each step of treatment scheme. Some refineries use the following basic treatment approach:

- Pretreatment to remove phenols, sulfides, mercaptans, ammonia and adjust pH (processes utilized are steam stripping, flue gas stripping, oxidation and neutralization)
- Removal of free oil and suspended solids by gravity
- Removal of emulsified oil, suspended solids, colloids and solids by coagulation and settling, sand filtration and gas flotation
- Trickling filters, activated sludge processes, oxidation ponds and aerated lagoons are biological organisms are biological organisms to convert dissolved organic matter to a settleable floc
- Tertiary treatment to remove dissolved organics and inorganics, color, odor and taste with foam fractionation, activated carbon, ion exchange, electrodialysis or ultrafiltration
- Disposal of high organic containing liquids or solids by combustion (incineration)
- Sludge arising from biological systems and solids separation processes are dewatered with the use of sand beds, vacuum filtration or centrifugation; sludge is then disposed of by landfill or incineration

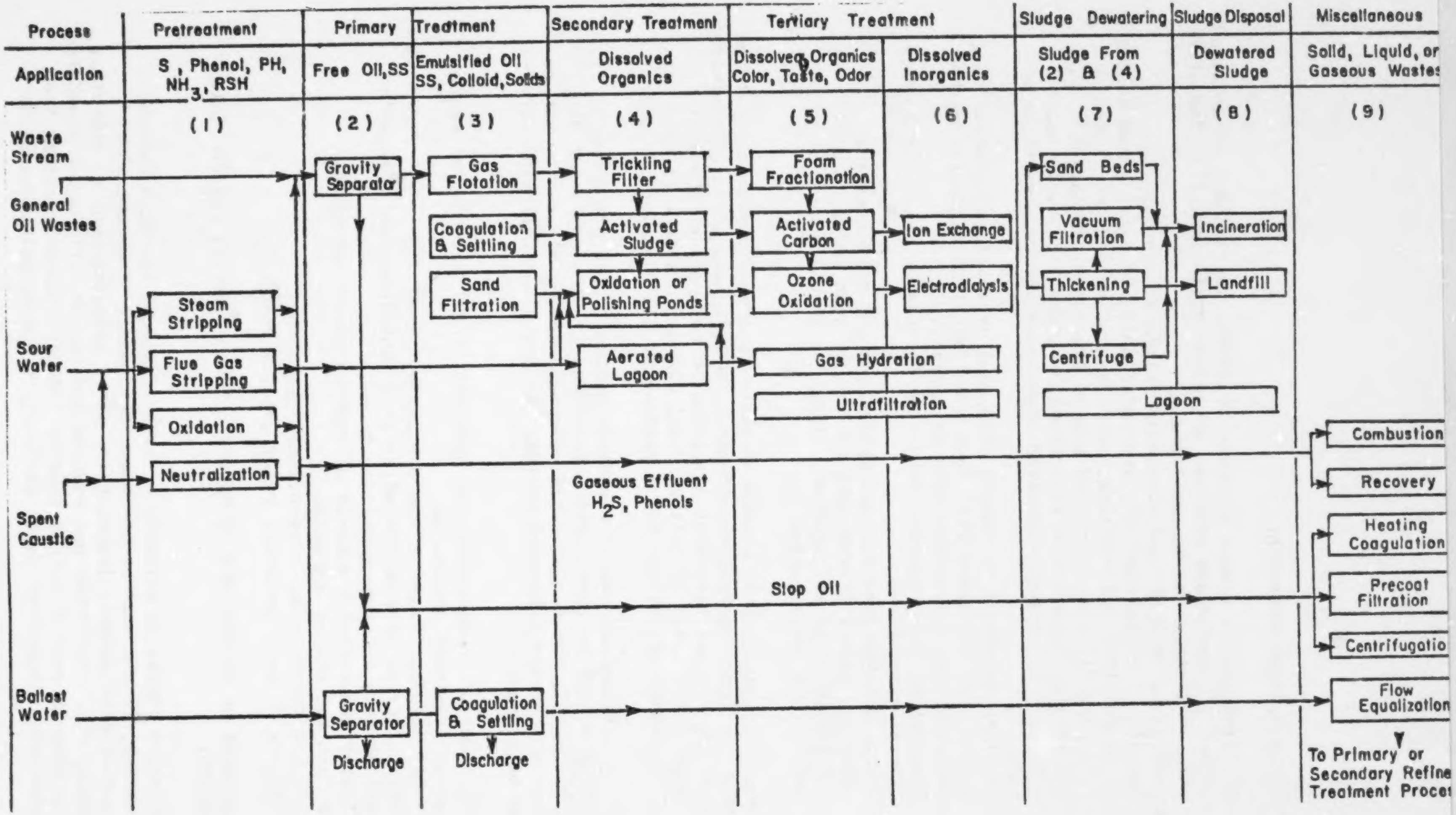
Figure 7 shows the diverse combinations of waste treatment processes that can be used to treat refinery wastewater streams. In addition, Table 20 estimates efficiencies of the various treatment practices on refinery effluent streams. By viewing Figure 7 and Table 20 collectively, one can obtain a first order estimation of treatment efficiency for a particular oil refining facility.

To determine the optimum wastewater treatment system, there are a number of key factors which should be considered. Specifically, the applicant should demonstrate in the EID, the analysis and selection method(s) used to arrive at the proposed wastewater treatment design. At least the following information should be presented:

- Systematic consideration and analysis of all alternative wastewater treatment approaches
- Waste loadings from various process systems
- Efficiency of alternative waste treatment sequences (system's reliability and susceptibility to upset)
- Energy and material demands of various treatment systems
- Margin for system expansion
- BAT for priority and conventional pollutants
- Ability to meet receiving water quality standards

III.C. STANDARDS OF PERFORMANCE TECHNOLOGY: END-OF-PROCESS CONTROL (AIR STREAMS)

Refinery operations result in emission of sulfur oxides, nitrogen oxides, particulate matter, CO and various hydrocarbons. Other emissions which lately have earned considerable interest are trace elements such as asbestos, mercury, benzene, etc. The USEPA has enacted New Source Performance Standards for various pollutants such as sulfur dioxide and particulates arising from petroleum refineries. State and local air quality and emission standards


Process
Pretreatment
Primary
Treatment
Secondary Treatment
Tertiary Treatment
Sludge Dewatering
Sludge Disposal
Miscellaneous
Application
S, Phenol, PH, NH_3, RSH
Free Oil,SS
Emulsified Oil SS, Colloid,Solids
Dissolved Organics
Dissolved Organics Color, Taste, Odor
Dissolved Inorganics
Sludge From (2) & (4)
Dewatered Sludge
Solid, Liquid, or Gaseous Waste
(1)
(2)
(3)
(4)
(5)
(6)
(7)
(8)
(9)
Waste Stream
General Oil Wastes
Sour Water
Spent Caustic
Ballast Water
Steam Stripping
Flue Gas Stripping
Oxidation
Neutralization
Gravity Separator
Gas Flotation
Coagulation & Settling
Sand Filtration
Trickling Filter
Activated Sludge
Oxidation or Polishing Ponds
Aerated Lagoon
Foam Fractionation
Activated Carbon
Ozone Oxidation
Gas Hydration
Ultrafiltration
Ion Exchange
Electrodialysis
Sand Beds
Vacuum Filtration
Thickening
Centrifuge
Lagoon
Incineration
Landfill
Combustion
Recovery
Heating Coagulation
Precoat Filtration
Centrifugatio
Flow Equalization
Gaseous Effluent H_2S, Phenols
Slop Oil
Gravity Separator
Coagulation & Settling
Discharge
Discharge
To Primary or Secondary Refine Treatment Proce

Source: US-DOI. 1967. The cost of clean water. Volume III, Industrial Waste Profile No. 5: Petroleum Refining. FWPCA Publication No. I.W.P.-5. Available from US-GPO, Washington, DC.

Figure 7. Sequence/substitute diagram of various wastewater treatment systems.

Table 20. Efficiency of oil refinery waste treatment practices based on effluent quality

	Process Influent[a]	BOD	COD	Separable Oil	Emulsified Oil	Phenol	Sulfide S	Suspended Solids	Chloride	Ammonia	Cyanide	pH	Toxicity	Temp. (°F)
Physical Treatment														
API separators	Raw waste	5-35[b]	5-30[b]	60-99	n.a.	Reduced	n.a.	10-50	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Earthern separators	Raw waste	5-50	5-40	50-99	n.a.	Reduced	n.a.	10-85	n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Evaporation	API effluent	100	100	n.a.	100	100	100	100	100	100	100	n.a.	n.a.	n.a.
Air flotation without chemicals	API effluent	5-25	5-20	70-95	10-40	n.a.	10-40 Reduced	n.a. 10-40	n.a. n.a.	n.a.	n.a.	n.a.	n.a.	n.a.
Chemical Treatment														
Air flotation with chemicals	API effluent	10-60	10-50	75-95	50-90	n.a.	Reduced	50-90	n.a.	Reduced	n.a.	n.a.	n.a.	n.a.
Chemical coagulation and precipitation	API effluent	10-70	10-50	60-95	50-90	n.a.	n.a.	50-90	n.a.	n.a.	n.a.	Altered	n.a.	n.a.
Biological Treatment														
Activated sludge	API effluent	70-95	30-70	n.a.	50-80	65-99	90-99	60-85	n.a.	50-95	65-99	Altered	Reduced	10-60
Aerated lagoons	API effluent	50-90	25-60	n.a.	50-80	65-99	90-99	0-40	n.a.	0-45	65-99	Altered	Reduced	10-90
Trickling filters	API effluent	50-90	25-60	n.a.	50-80	65-99	80-99	60-85	n.a.	50-99	65-99	Altered	Reduced	10-60
Oxidation ponds	API effluent	40-80	20-50	n.a.	40-70	65-99	70-90	20-70	n.a.	20-90	65-99	Altered	Reduced	10-90
Activated carbon	Secondary[c] effluent	50-90	50-90	n.a.	50-90	80-99	80-99	n.a.	n.a.	10-30	80-99	n.a.	Reduced	n.a.
Ozonation	Secondary effuent	50-90	50-90	n.a.		80-99	80-99	n.a.	n.a.	10-30	80-99	n.a.	Reduced	n.a.

[a] Most probable process influent-indicates the kind or extent of prior treatment required for efficient utilization of the specific process under consideration.

[b] BOD and COD from separable oil not included.

[c] Chemical or biological treatment.

LEGEND: API = American Petroleum Institute, n.a. = Not Applicable

Source: US-DOI. 1967. The cost of clean water. Volume III, Industrial Waste Profile No. 5: Petroluem Refining. FWPCA Publication No. I.W.P.-5. Available from US-GPO, Washington, DC.

also may be imposed. To comply with these regulations, the operator of a new source refinery has available various air pollution control devices and techniques to reduce emissions to within allowable levels. At a minimum, the following air pollution control measures for each pollutant should be considered and described in the EID:

- Hydrocarbon emissions can be limited through the use of floating-roof tops; manifolding purge lines to a recovery system (condenser or carbon absorber) or to a flare (see Figure 8); vapor recovery systems on loading facilities; preventive maintenance; enclosed waste treatment plant; mechanical seals on compressors and pumps, and trained and cognizant personnel. A typical scrubbing system for emissions from air-blown asphalt stills is shown in Figure 9.
- Particulates can be controlled with the use of wet scrubbers and high-efficiency mechanical collectors (cyclones, bag houses); electrostatic precipitators on catalyst regenerators and power plant stacks; controlled combustion to reduce smoke; controlled stack and flame temperatures, and improved burner and incinerator design.
- Carbon monoxide emissions can be controlled at the catalytic cracker and fluid coker units with a CO boiler and at other sites through proper furnace and burner design.
- Odor controls include a good preventive maintenance program; the treatment of H_2S-rich wastewater streams from the catalytic crackers; gas-processing units and vacuum distillation towers; and the flaring of H_2S, mercaptans, other sulfides and other odor-producing compounds.
- Sulfur dioxide emissions can be controlled primarily through the burning of low-sulfur fuels in furnaces and boilers, the wet scrubbing of high-sulfur dioxide flue gases, and the desulfurization of fuels before use.
- Nitrogen oxide emissions can be controlled through an improved combustion process (i.e., lower flame temperature, less excess air), low nitrogen fuel burning, and good stack dispersion.

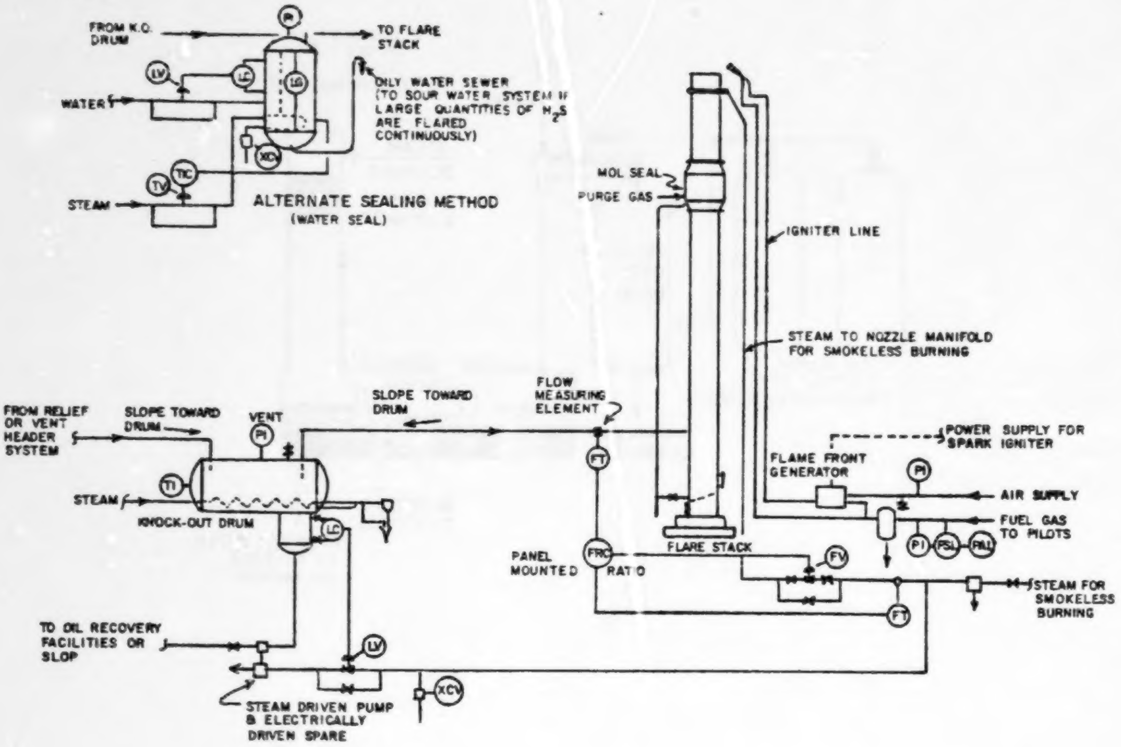
Table 21 presents a summary of the principal emission control devices currently employed at oil refinery facilities.

Other emission control technologies that currently are not used widely commercially, but are emerging include:

- Amine scrubbing
- Hot potassium carbonate process
- Sulfnol process (Shell Oil Co.)
- Seaboard and vacuum carbonate process (Koppers Co.)
- Phosphate process (Shell Development Co.)
- Wet iron box process
- Thylox process
- Dolomite acceptor process

III.D. STATE OF THE ART TECHNOLOGY: END-OF-PROCESS CONTROLS (SOLID WASTE DISPOSAL)

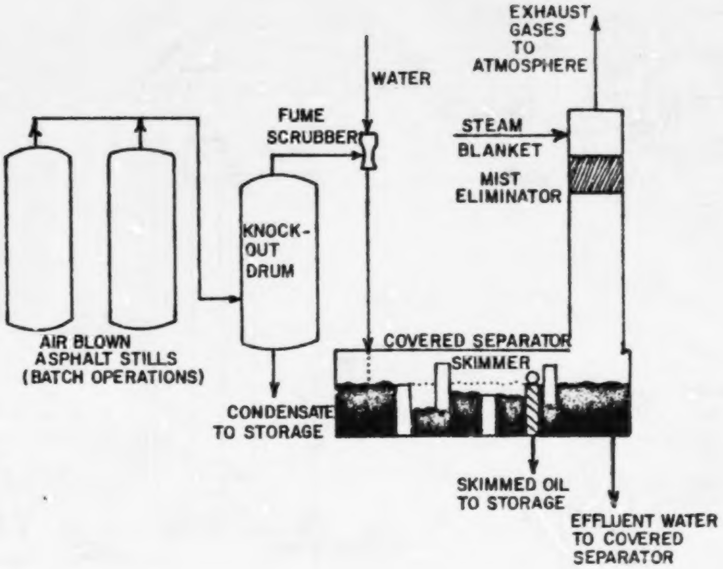
Petroleum refineries generate an estimated 625,000 metric tons per year of


FROM K.O. DRUM
PI
TO FLARE STACK
LV
LC
LG
WATER
OILY WATER SEWER (TO SOUR WATER SYSTEM IF LARGE QUANTITIES OF H_2S ARE FLARED CONTINUOUSLY)
XCV
TIC
TV
STEAM
ALTERNATE SEALING METHOD
(WATER SEAL)
MOL SEAL
PURGE GAS
IGNITER LINE
STEAM TO NOZZLE MANIFOLD FOR SMOKELESS BURNING
FROM RELIEF OR VENT HEADER SYSTEM
SLOPE TOWARD DRUM
VENT
PI
SLOPE TOWARD DRUM
FLOW MEASURING ELEMENT
FT
TI
STEAM
KNOCK-OUT DRUM
LC
POWER SUPPLY FOR SPARK IGNITER
FLAME FRONT GENERATOR
PI
AIR SUPPLY
FUEL GAS TO PILOTS
PI
PSL
PAL
PANEL MOUNTED
FRC
RATIO
FLARE STACK
FV
FT
STEAM FOR SMOKELESS BURNING
TO OIL RECOVERY FACILITIES OR SLOP
LV
XCV
STEAM DRIVEN PUMP & ELECTRICALLY DRIVEN SPARE

Source: API. 1973. Hydrocarbon emissions from refineries. Publication 0.928, Washington, D.C.

Figure 8. Typical flare installation.

Note: This represents an operable system arrangement and its components. Arrangement of the system will vary with the performance required. Correspondingly, the selection of types and quantities of components, as well as their applications, must match the needs of the particular plant and its specifications.


EXHAUST GASES TO ATMOSPHERE
WATER
FUME SCRUBBER
STEAM BLANKET
MIST ELIMINATOR
KNOCK-OUT DRUM
AIR BLOWN ASPHALT STILLS (BATCH OPERATIONS)
COVERED SEPARATOR
SKIMMER
CONDENSATE TO STORAGE
SKIMMED OIL TO STORAGE
EFFLUENT WATER TO COVERED SEPARATOR

Source: API. 1973. Hydrocarbon emissions from refineries. Publication 0.928 Washington, D.C.

Figure 9. Simplistic low diagram for typical scrubbing system for emission control from air-blown asphalt stills.

Table 21. Summary of emission control technologies currently in use for various air pollutants generated from refinery processes.

PROCESS	EMISSION	UNCONTROLLED LEVEL	CONTROL TECHNOLOGY	APPROX. CONTROL EFFICIENCY
Catalyst Regeneration	Particulates	90-350 Lb/10^3 BBL Fresh Feed	Cyclones	65-85%
			Multiple Cyclones	70-90%
			Electrostatic Precipitation	> 95%
			Wet Scrubber (high energy venturi)	> 90%
	SO_x	310-525 Lb/10^3 BBL Fresh Feed	Wet Scrubber (high energy venturi)	> 80%
	CO	13,700	Waste Heat Boiler	> 99%
Fluidized Coking	Particulates	520	Cyclones	65-85%
			Multiple Cyclones	70-90%
			Electrostatic Precipitation	> 95%
Boilers/ Process Heaters	SO_x	Essentially all fuel sulfur is emitted as SO_x	Fuel Blending/Switching	
	Particulates	0.1-10 Lb/10^3 Lb Fuel Burned	Electro. Precip.	> 95%
Sulfur Recovery	SO_2/H_2S	5-10% of Sulfur Input	Additional Claus Stages	Total Process Achieves S Removal of 97%
			Tail Gas Scrubbing	> 90%
			Tail Gas Recovery (IFP, Beagon, Cleanair)	> 90%
Storage Tanks	Hydrocarbon	1-10 Lb/day/10^3 gallons throughput	Floating Roof	99%
			Pressurized Tanks	
			Vapor Recovery	90-95%
Loading Facilities	Hydrocarbon	1-12 Lb/10^3 Gallons Transferred	Submerged Loading	50-70%
Incineration	Particulates	Variable	Cyclones	65-85%
			Multiple Cyclones	70-90%
			Wet Scrubber - Packed Tower	>90%
			Venturi	>90%
Light Ends	Hydrogen Methane	Variable	Flare	

waste (dry weight) in the course of distilling crude petroleum and processing of petroleum products (USEPA 1976d). The volume of waste generated as well as the economics of material recovery are determined to a large degree by the type, age, and condition of process units and the market for product "mix". Further, refineries in different geographic areas encounter widely varying requirements and problems associated with their individual solid waste streams. Treatment and disposal methods used in oil refineries are contingent upon the nature, concentration, and quantities of waste generated, as well as upon the potential toxicity or hazardousness of these materials. Pollution control methods are further affected by geographic conditions, transportation distances, disposal site hydrogeological characteristics, and regulatory agency requirements.

Much of the material wasted by refineries only 20 to 25 years ago has either been eliminated by process changes, is now processed into marketable products, is recycled for reprocessing, or is sold to secondary material processors for extraction of valuable constituents. Noble metal catalysts, caustic solutions containing recoverable quantities of phenolic compounds, and some alkylation sludges reprocessed for sulfuric acid are examples of such waste streams. The types of wastes requiring disposal have been listed and described in Section II.C. of this report.

The paragraphs that follow discuss the primary treatment and disposal techniques for handling solid wastes from refineries. These and any other developing technologies should be considered by the permit applicant prior to selection of the proposed disposal method.

III.D.1. Landfilling

Landfilling is presently the most widely used method for disposing of all types of petroleum refinery waste products. The environmental adequacy of this method is contingent not only upon the types and characteristics of generated wastes, but also upon methods of operation and on specific site geologic and climatologic conditions. Of all the land disposal methods used by the refining industry, perhaps the greatest variations in operations and in site suitability are experienced with landfills. Landfilling operations range from open dumping of construction and refinery debris to controlled disposal in secure landfills. However the precise impact of solid waste disposal depends on the nature of the waste (inert construction waste may not pose a problem even in an open dump) and the landfill (secure landfills involve control of wastewater, groundcover, plot padding, etc.)

The environmental adequacy of a refinery waste landfill is affected by the following operational and management practices:

- The extent of segregation of wastes to prevent mixing of incompatible compounds, such as solids containing heavy metals with acids, or solutions with other wastes which together produce explosions, heat, or noxious gases
- The extent to which liquid or semi-liquid wastes are blended with soil or refuse materials to suitably absorb their moisture content and reduce their fluid mobility within the landfill
- The extent to which acids or caustic sludges are neutralized to minimize their reactivity

- Selection of sites in which the active fill area is large enough to allow efficient truck discharging operations, as well as to assure that blended wastes may be spread, compacted, and covered daily with approximately six inches of cover soil; A site operated in this manner is called a sanitary landfill
- The routing of surface waters around the landfill site and sloping of cover soil to avoid on-site runoff and erosion

III.D.2. Landspreading

Landspreading is a relatively inexpensive method of disposal of petroleum refinery wastes which is being used by an increasing number of refineries. The success of landspreading in the warm southwestern states (due to higher ambient temperatures and therefore faster biological degradation) has prompted many U.S. refineries in colder climates to experiment with this method of disposal. Many refineries, however, which employ landspreading have done so for only about one to three years; only a few have a working experience with this process for a longer period of time.

Historically, refineries have been concerned largely with possible oil contamination of ground and surface waters which may result from landspreading. Few refineries have considered other environmental effects which may result from this operation. The real concern is not only the recognized short-term oil problem and incomplete treatment of organic acids and other intermediate byproducts, but the long-term implications of trace metal accumulation in the soil over long periods of operation. The problem posed by disposal of heavy metals on or in land largely is the same for all treatment and disposal technologies. The major difference is a quantitative one, with repeated applications of oily wastes to the same land areas potentially producing greater concentrations of heavy metals than result from other disposal methods. In a confined secure disposal area, these heavy metals and other hazardous organic acids or degradation products do not pose the same level of hazard to the environment. Landspreading appears to be emerging as an important method for disposal of certain refinery wastes and should be carefully assessed during the EID process.

III.D.3. Lagoons, Ponds, Sumps, and Open Pits

Lagoons, ponds, sumps and open pits have been used for many decades by the petroleum refining industry for the disposal of liquid and semi-solid waste.

The expediency of past disposal by simply dumping wastes into lagoons or sumps has turned into a major disposal problem in many parts of the country (Oil and Gas Journal 1972). The demand for elimination of these unsightly sumps has been prompted by many factors, among which, are the following:

- The need for additional land for refinery expansion
- Increasing land values which demand that land be put to a higher and more profitable use
- The envelopment of these lands by urban areas, and the resulting increased potential dangers to people
- Increasingly stringent regulatory agency requirements
- The desire to eliminate potentially catastrophic situations which may arise as a result of flooding rivers carrying large amounts of petroleum sludge with them

Action is now being taken by a number of states (California, Oklahoma, Texas, and Pennsylvania), to phase out the use of sumps and lagoons as permanent disposal methods, allowing them to be used only as temporary retention or treatment ponds. They are thus being relegated to use as wastewater treatment units, such as primary and secondary clarifiers, biostabilization or oxidation ponds, or thickening basins. Other uses included evaporation ponds or emergency diversion basins. As wastewater treatment requirements have become more stringent, many simple facultative and anaerobic lagoons have been converted into aeration basins by the addition of mechanical aerators. Because of their simplicity and ease of construction, many of the newer refineries make considerable use of earthen or lined lagoons as primary or secondary sedimentation chambers, aeration basins, oxidation ponds, storm runoff ponds, and emergency oil spill retention basins.

The environmental acceptability of lagoons for any of the prescribed purposes is very much dependent upon the method and materials of construction, specific local hydrogeologic conditions, and the types of waste which are handled. The potential for significant contamination of underlying water aquifers from many inadequately lined lagoons, both old and new, is appreciable because of improper location and inadequate safeguards. Although many of the units are acceptable, the applicant should ascertain that adequate design and construction practices are followed in areas with high water tables, porous soils, or other environmental constraints.

III.D.4. Leaded Gasoline Sludge Treatment and Disposal

Because organic lead vapors are known to be toxic at various concentrations (approximately 0.075 to 0.15 mg/m^3, depending on lead compound), special procedures have been developed exclusively for the treatment and disposal of leaded gasoline sludges which accumulate in aviation and motor gasoline storage tanks. Gasoline product storage tank sludges are disposed by landfill or landfarming. This involves the construction of a dike surrounding the tank to be cleaned. After the tank contents (except sludge) is pumped to another tank, the remaining sludge is either pumped into the dike for weathering and degradation or is transported to a weathering pad elsewhere within the refinery. It subsequently is rotodisked into the soil or buried on refinery property. Careful monitoring of such sites is required since such practices have not been totally shown to be safe. The volume of leaded-gasoline sludge generated is quite small and the frequency of cleaning is subsequently low - on the order of every one to ten years. Even then, the frequency of tank cleaning is dictated more by required tank maintenance than by need for sludge removal.

III.D.5. Incineration

Incineration of semi-solid and solid organic containing refinery-generated wastes requires a special type of system which provides adequate detention times, stable combustion temperatures, sufficient mixing, and high heat transfer efficiency. A fluidized bed is one of the few systems which can satisfy all these criteria. In addition, the fluidized bed of heated solids serves as a heat sink to ignite volatilized hydrocarbons, thereby reducing or eliminating the possibility of creating an extremely dangerous explosive mixture of unburned gaseous hydrocarbons and air. The material to be incinerated can be injected either into the fluidized bed or immediately above it. Refinery wastes known to be incinerated by such systems include spent caustic solutions, API separator bottoms, DAF float, waste bio sludge, and slop oil emulsion solids. Experience has shown that the reaction is self-sustaining if the thermal content of the total wastes incinerated exceeds about 29,000 BTU per gallon. Normal range of operating temperature is from 1300 to 1500 F. Loss of fluidization and plugging of the bed is still a major problem in the operation of these units. Reduced temperatures permit discharge of uncombusted organics. There are a variety of other incineration processes in any standard sanitary engineering text.

III.D.6. Deep Well Disposal

Subsurface or deep well injection is a disposal method which originated with the oil and gas extraction industry. Brines, separated from the extracted gas and oil, are pumped back into the formations from which the fluid is originally taken, thus restoring the formation pressure and facilitating the extraction of additional gas and oil. Gradually the injection practice has been extended to include a multitude of wastes which would be difficult to dispose of by any other means.

Several refineries in the Southern California area are known to inject waste brines into deep wells. Deep well injection capital and operating costs can be considerable. The future of deep well injection has been clouded by recent legal and regulatory agency decisions (Ricci 1974; Ruckelshaus 1973). Deep well disposal must follow the guidelines established by the state Underground Injection Control Program.

III.D.7. Ocean Disposal

The 1971 Dillingham report (Smith and Brown 1971) for the EPA on ocean disposal of barge-delivered liquid and solid wastes reported that approximately 500,000 tons of refinery wastes have been dumped into the ocean. The Marine Protection Act of 1972 (PL 92-532) has transferred regulation and control of all ocean dumping from the district office of the U.S. Corps of Engineers to the Environmental Protection Agency. Ocean disposal of certain prescribed hazardous wastes is prohibited. Permits for other less hazardous wastes are becoming increasingly difficult to obtain, as well, as alternative methods of ultimate disposal become available. Regulations will force the end of ocean disposal.

III.D.8. Special Treatment and/or Disposal Practices

A procedure for reducing the volume of crude tank bottoms is the use of poly electrolytes to promote phase separation. The process is performed prior to cleaning the tanks, at which time any crude oil remaining in the tank is pumped out to the sludge layer and replaced with approximately 5,000 to 6,000 barrels of "Canadian Condensate" or "off-gas" from field wells. The material in the tank is heated with steam and mixed with the crude tank bottoms to a temperature of approximately 130°F to recover crude fractions. The residue is used as fuel.

Another special practice that may be used for treatment of both liquid and solid wastes is that of chemical fixation. Among the chemical fixation methods which are in use in the petroleum refining industry are the following:

- Use of chemical coagulants to create an insoluble precipitate. Often the one waste stream that is deliberately treated to produce a chemically inert precipitate is the routing of cooling tower blowdown containing hexavalent chromium through the API separator where available sulfides bring about the reduction of hexavalent chromium to trivalent chromium. From the API separator, reduced chromium ion is routed through the spent lime slurry tank where it is converted to chromium hydroxide, an insoluble precipitate. The lime sludge containing the precipitated hydroxide usually is removed by vacuum truck.
- Sorption of solvent-like hydrocarbons
- The use of a variety of chemical systems have been devised to overcome the fluidity of certain petroleum wastes. These chemical systems react with various components of the waste to form a semi-solid material which effectively encapsulates or otherwise ties up the harmful constituents. The majority of these methods tend to isolate the material from the environment by either isolating the waste component as a solid mass, drying out the liquid, or achieving some form of chemical bonding or sorption. Chemical fixation or solidification is used by a few refineries to solve specific disposal problems, such as the permanent disposal of environmentally unacceptable (because of leaching) lagoons filled with API separator bottoms or crude tank bottoms. The Chemfix Process is an example of such a chemical system. It consists of adding metered quantities of reactants to 300 to 500 gallons of waste slurry at intervals of one minute, and mixing to obtain homogeneity. The volume of reactant added to the waste is usually less than 10% and often below 5% by volume. If cement were used to solidify the same waste, a volume increase of about 100% would typically be required to obtain a solid waste containing the entire liquid portion. The process is continuous and occurs at ambient temperature and pressure.

III.E. TECHNOLOGIES FOR CONTROL OF POLLUTION FROM CONSTRUCTION SITES

The major pollutant at a construction site is loosened soil that finds its way into the adjacent water bodies and becomes "sediment." This potential problem of erosion and sedimentation is not unique to refinery construction, but applies widely to all major land disturbing activities. Common remedial measures include, but are not limited to, proper planning at all stages of development and application of modern control technology to minimize the production of huge loads of sediment. Specific control measures include:

- The use of paved channels or pipelines to prevent surface erosion
- Staging or phasing of clearing, grubbing, and excavation activities to avoid high rainfall periods
- The use of storage ponds to serve as sediment traps, where the overflow may be carefully controlled
- The use of mulch or seeding immediately following disturbance

If the applicant chooses to establish temporary or permanent ground cover, grasses normally are more valuable than shrubs or trees because of their extensive root systems that entrap soil. Grasses may be seeded by sodding, plugging, or sprigging. During early growth, grasses should be supplemented with mulches of wood chips, straw, and jute mats. Wood fiber mulch also has been used as an antierosion technique. The mulch, prepared commercially from waste wood products, is applied with water in a hydroseeder.

IV. OTHER CONTROLLABLE IMPACTS

IV.A. AESTHETICS

New source petroleum refineries may be large and complex facilities occupying an area of up to several hundred acres. Cooling towers, air emission stacks, material storage and handling areas, and other plant components may detract considerably from the surrounding landscape. Particularly in rural and suburban areas, this configuration may represent a significant intrusion on the landscape; existing industrial areas would be less affected. Measures to minimize the impact on the environment should be developed primarily during site selection and design. The applicant should consider, as applicable, the following factors to reduce potential aesthetic impacts:

- Existing Nature of the Area--The topography and major land uses in the area of the candidate sites can be important aesthetic considerations. Natural topographic conditions perhaps could serve to screen the refinery from public view. A lack of topographic relief will require other means of minimizing impact, such as regrading or establishing (or leaving) vegetation buffers. Analysis of major land uses may be useful to assist in the design and appearance of the facility. Design of the refinery should reflect the nature of the area in which it is to be placed (i.e., the structures should blend into the existing environment as much as possible). The use of artists' conceptions, preferably in color, will be most useful in determining the visual impact and appropriate mitigation measures and should be included in the EID.
- Proximity of Sites to Parks and Other Areas Where People Congregate for Recreation and Other Activities -- The location of these areas should be mapped and presented in the EID. Representative views of the plant (site) from observation points and the visual effects on these areas should be described in the EID in order to develop the appropriate mitigation measures.
- Pipeline and Transportation System -- The visual impact of new pipelines, access roads, railroad lines, barge loading/unloading facilities, etc. on the landscape should be considered. Specific locations, construction methods and materials, maintenance activities and mitigation plans should be discussed.
- Creation of Aesthetically Pleasing Areas -- In some cases, the development of a refinery will create aesthetically pleasing areas. Screening the facility by vegetation or using the natural topography may improve the appearance of an area. Creation of open space and development of recreational facilities also can improve the area. Such positive impacts should be described in the EID.

IV.B. NOISE

Oil refineries may have a significant impact on ambient noise levels at the fence line. Among the major sources of noise in a refinery are the following:

- Compressors
- Pumps and motors
- Flares

In addition, construction activities also generate substantial noise levels. The applicant should undertake a site ambient noise survey prior to construction. This survey should be undertaken according to standard procedures (Miller 1976). Then fence line noise levels should be projected during construction and operation using estimates based on active noise levels of various equipment as determined from other refineries and from equipment suppliers.

Noise levels can be reduced by:

- Use of equipment designed to reduce emission levels
- Shielding equipment
- Good maintenance
- Shielding the plant with a noise barrier

To evaluate noise generated from a proposed site, the applicant should follow the sequence listed below:

- Identify all noise-sensitive land uses and activities adjoining the site
- Identify existing noise sources, such as traffic, aircraft flyover, and other industry, in the study area as defined
- Identify all applicable State and/or local noise regulations
- Estimate the noise level of the refinery during construction and operation and compare with the existing community noise levels and the applicable noise regulations
- Calculate the change in community noise levels resulting from construction of the refinery
- Assess the noise impact of the refinery operational noise and construction noise, and, if warranted, propose noise abatement measures to reduce the impact

IV.C. SOCIOECONOMIC

Introduction of a large oil refining facility into a community may cause economic and social changes. Therefore, it is necessary for an applicant to understand the types of impacts or changes that may occur so that they can be evaluated adequately in the EID. The importance of these changes usually depends on the nature of the area where the refinery is located (e.g., size of existing community, existing infrastructure). Normally, however, the significance of the changes caused by a refinery of a given size will be greater in a small, rural community than in a large, urban area. This is primarily because a small, rural community is likely to have a nonmanufacturing economic base and a lower per capita income, fewer social groups, a more limited socioeconomic infrastructure, and fewer leisure pursuits than a large, urban area. There are situations, however, in which the changes may not be significant in a small community and, conversely, in which they may be considerable in an urban area. For example, a small community may have had a manufacturing (or natural resource) economic base that has declined. As a result, such a community may have a high incidence of unemployment in a skilled labor force and a surplus of housing. Conversely, a rapidly growing urban area may be severly strained if a new oil refinery is located there.

The rate at which the changes occur (regardless of the circumstances) also is an important determinant of the significance of the changes. The applicant should distinguish clearly between those changes occasioned by the construction of the plant and those resulting from its operation. The former changes could be substantial but usually are temporary; the latter may or may not be substantial but normally are more permanent in nature.

During the construction phase, the impact usually will be greater if the project requires large numbers of construction workers to be brought in from outside the community than if local, unemployed workers are available. The impacts are well known and include:

- Creation of social tension
- Demand for increased housing, police and fire protection, public utilities, medical facilities, recreational facilities, and other public services
- Strained economic budget in the community where existing infrastructure becomes inadequate

Various methods of reducing the strain on the budget of the local community during the construction phase should be explored. For example, the company itself may build the housing and recreation facilities and provide the services and medical facilities for its imported construction force. Or the company may prepay taxes and the community may agree to a corresponding reduction in the property taxes paid later. Alternatively, the community may float a bond issue, taking advantage of its tax-exempt status, and the company may agree to reimburse the community as payments of principal and interest becomes due.

During refinery operation, the more extreme adverse changes of the construction phase are likely to disappear. Longer run changes may be profound, but less extreme, because they evolve over a longer period of time and may be both beneficial and harmful.

The permit applicant should document fully in the EID the range of potential impacts that are expected and demonstrate how possible adverse changes will be handled. For example, an increased tax base generally is regarded as a positive impact. The revenue from it usually is adequate to support the additional infrastructure required as the operating employees and their families move into the community. The spending and respending of the earnings of these employees has a multiplier effect on the local economy, as do the interindustry links created by the new refinery. Socially, the community may benefit as the increased tax base permits the provision of more diverse and higher quality services and the variety of its interests increases with growth in population. Contrastingly, the transformation of a small, quiet community into a larger, busier community may be regarded as an adverse change by some of the residents who chose to live in the community, as well as by those who grew up there and stayed, because of its amenities. The applicant also should consider the economic repercussions if, for example, the quality of the air and water declines as a result of various waste streams from the new source oil refinery and its ancillary facilities.

In brief, the applicant's framework for analyzing the primary and secondary socioeconomic impacts of constructing and operating a refinery must be comprehensive. Most of the changes described should be measured to assess fully the potential costs and benefits. The applicant should distinguish clearly between the short term (construction) and long term (operation) changes, although some changes may be common to both (e.g., the provision of infrastructure) because the significance of the changes depends not only on their absolute magnitude, but also on the rate at which they occur.

The applicant should develop and maintain close coordination with State, regional, and local planning and zoning authorities to ensure full understanding of all existing and/or proposed land use plans and other related regulations.

IV.D. ENERGY SUPPLY

The impact of a petroleum refinery on local energy supplies will depend largely on the type of processes proposed and the ancillary facilities. The applicant should evaluate the energy efficiencies of all processes considered during project planning and then consider the alternatives. Feasible design modifications also should be considered in order to reduce energy consumption.

At a minimum, the applicant should provide the following information:

- Total external energy demand for operation of the refinery
- Total energy available on site
- Energy demands by type
- Proposed measures to reduce energy demand and increase plant efficiency

IV.E. IMPACT AREAS NOT SPECIFIC TO PETROLEUM REFINERIES

The intent of the preceding sections was to provide guidance to new source NPDES permit applicants on those impact areas that are specific to or representative of new source refinery operations. It is recognized that many impacts resulting from the construction and operation of an oil refinery are similar to impacts associated with many other new sources industries; therefore, no effort has been made to discuss these types of impacts, but instead, to reference other more general guideline documents. For example, general guidelines for developing a comprehensive inventory of baseline data (preproject conditions) and a general methodology for impact evaluation are contained in Chapters 1 and 2 of the EPA document, Environmental Impact Assessment Guidelines for Selected New Source Industries. Although broad in scope, this document and other appropriate guidance materials should be used by the applicant for assistance in evaluating impacts which are not unique to petroleum refineries.

V. EVALUATION OF AVAILABLE ALTERNATIVES

V.A. SITE ALTERNATIVES

As with most industries, the petroleum refinery industry locates plants on the basis of market demand for specific products, convenience to raw materials, an adequate labor force and water supply, proximity to energy supplies and transportation, minimization of environmental problems, and other factors. Preliminary site selection activities should occur before the EID document is prepared. A variety of candidate sites initially should be considered and, following a detailed analysis of each one, a preferred site should be selected that best satisfies project objectives and that is expected to result in the least adverse environmental impact.

The factors considered in selecting each site, and especially those that influenced a positive or negative decision on its suitability, should be documented carefully in the permit applicant's EID. Adequate information on the feasible alternatives to the proposed site is a necessary consideration in issuing, conditioning, or denial of an NPDES permit.

Specifically the advantages and disadvantages of each alterntive site must be catalogued with due regard to preserving natural features such as wetlands and other sensitive ecosystems and to minimizing significant adverse environmental impacts. The applicant should ascertain that all impacts are evaluated as to their significance, magnitude, frequency of occurrence, cumulative effects, reversibility, secondary or induced effects, and duration of impacts. If site selection could influence accidents or spills of hazardous or toxic substances, it should be discussed fully in the EID.

In the EID the applicant also should display the alternative site locations on maps, charts, etc., that show the refinery layout, environmental conditions, and other relevent site information. A consistent identification system for the alternative sites should be established and retained on all graphic and text material. Pertinent and useful information might include, but is not limited to:

- All candidate areas and sites considered by the applicant
- Major centers of population density (urban, high, medium, low density, or similar scale)
- Water bodies suitable for use in cooling system and/or in other systems
- Railways, highways (existing and planned), and waterways suitable for the transportation of fuels, wastes, raw materials, products, and byproducts
- Important topographic/geological features (mountains, marshes, rock outcroppings)
- Dedicated land use areas (parks, historic sites, wilderness areas, testing grounds, airports, etc.)
- Other sensitive environmental areas (wetlands, prime agricultural lands, critical wildlife habitat, etc.)
- Major interconnections with power suppliers
- Other industrial complexes, significant mineral deposits, and mineral industries

Quantification, although desirable, may not be possible for all factors because of lack of adequate data. Under such circumstances, qualitative and general comparative statements, supported by documentation, may be used. Where possible, experience derived from operation of other refineries at the same site, or at an environmentally similar site, may be helpful in appraising the nature of expected environmental impacts.

Economic estimates should be based at least on a preliminary conceptual design that considers how construction costs are affected by such site-related factors as topography, geology, and tectonics; distance from water supply source, and cooling tower configuration as determined by meteorological factors.

Once a specific site for location of the refinery is proposed it may receive considerable opposition locally, statewide or even nationally. Such opposition may derive from the fact that the proposed refinery would significantly impact a unique recreational, archaeological, or other important natural or manmade resource. It may destroy the rural or pristine character of an area or conflict with planned development for the area. It may have significant geological and hydrological constraints. It may be subject to periodic flooding, hurricanes, earthquakes, or other natural disasters.

Therefore, if the proposed site location proves undesirable, then alternative sites from among those originally considered should be reevaluated or new sites should be identified and evaluated. Expansion or technological changes at an existing plant site may be a possible alternative. Therefore, it is critical that a permit applicant systematically identify and assess all feasible alternative site locations as early in the planning process as possible.

Several different agencies may be able to assist the applicant in evaluating potential areas for location of the new source industry. Those include:

- State, regional, county, or local zoning or planning commissions can describe their land use programs and where variances would be required. Federal lands are under the authority of the appropriate Federal land management agency (Bureau of Reclamation, U.S. Forest Service, National Park Service, etc.)
- State or regional water resource agencies can provide information relative to water appropriations and water rights
- Air pollution control agencies can provide assistance relative to air quality allotments and other air-related standards and regulations
- The Soil Conservation Service and State Geological Surveys can provide data and consultation on soil conditions and geologic characteristics

If the State has an industry siting law, the requirements should be cited and any applicable constraints described.

V.B. PROCESS ALTERNATIVES

Typically, when the decision is made to expand refining capacity--either through a new refinery or an addition to an existing one--the type of facility to be constructed is already fixed; that is, the demand for any given product which initiated the decision would have dictated the type of process to be used. The limitation on process alternatives is not as severe as it once was because of improved process versatility and the development of new process technologies.

In addition to demand, process alternatives should be selected on the basis of economics, engineering, and environmental considerations. The applicant should present clearly and systematically in the EID, the methodology used to identify, evaluate, and select the preferred process alternative. All process alternatives that appear practical should be evaluated on the basis of criteria such as:

- Land requirements, fuel storage facility requirements, and waste storage facility requirements
- Release to air of CO, sulfur dioxide, nitrogen oxides, hydrogen sulfide or other potential pollutants, subject to Federal, State, or local limitations
- Releases to water of heat, chemicals, and trace metals, etc. subject to Federal, State, and local regulations
- Water consumption rate
- Fuel consumption and the generation of wastes with associated waste treatment and disposal problems
- Economics
- Aesthetic considerations for each alternative process
- Reliability and energy efficiency of process

A tabular or matrix form of display often is helpful to compare costs and benefits of feasible process alternatives. Processes which are not feasible should be dismissed with an objective explanation for rejection.

V.C. NO-BUILD ALTERNATIVE

In all proposals for industrial development, the applicant must consider and evaluate the alternative of not constructing the proposed new source facility. Because this analysis is not unique to the development of petroleum refineries, no specific guidance is provided as part of this document. The permit applicant, therefore, is referred to Chapter IV (Alternatives to the Proposed New Source) in the EPA document, Environmental Impact Assessment Guidelines for Selected New Sources Industries, which was published in October 1975.

VI. REGULATIONS OTHER THAN POLLUTION CONTROL

The applicant should be aware that various regulations other than pollution control may apply to the siting and operation of new petroleum refineries. The applicant should consult with the appropriate EPA Regional Administrator regarding applicability of such regulations to the proposed new source. Some Federal Regulations that may be pertinent to a proposed facility are:

- Coastal Zone Management Act of 1972 (16 USC 1451 et seq.)
- Fish and Wildlife Coordination Act of 1974 (16 USC 661-666)
- USDA Agriculture Conservation Service Watershed Memorandum 108 (1971)
- Wild and Scenic Rivers Act of 1969 (16 USC 1274 et seq.)
- Flood Control Act of 1944
- Federal-Aid Highway Act, as amended (1970)
- Wilderness Act of 1964
- Endangered Species Preservation Act, as amended (1973) (16 USC 1531 et seq.)
- National Historical Preservation Act of 1974 (16 USC 470 et seq.)
- Executive Order 11593 (Protection and Enhancement of Cultural Resources)
- Executive Order 11980 (Floodplain management)
- Executive Order 11990 (Protection of wetlands)
- Archaeological and Historic Preservation Act of 1974 (16 USC 469 et seq.)
- Procedures of the Council on Historic Preservation (1973)(39FR3367)
- Occupational Safety and Health Act of 1970

In connection with these regulations, the applicant should place particular emphasis on obtaining the services of a recognized archaeologist to determine the potential for disturbance of an archaeological site, such as an early Indian settlement or a prehistoric site. The National Register of Historic Places also should be consulted for historic sites such as battlefields. The applicant should consult the appropriate wildlife agency (State and Federal) to ascertain that the natural habitat of a threatened or endangered species will not be affected adversely.

From a health and safety standpoint, most industrial operations involve a variety of potential hazards and to the extent that these hazards could affect the health of plant employees, they may be characterized as potential environmental impacts. All refinery operators should emphasize that no phase of operation or administration is of greater importance than safety and accident prevention. Company policy should provide and maintain safe and healthful conditions for its employees and establish operating practices that will result in safe working conditions and efficient operation.

The refinery must be designed and operated in compliance with the standards of the U.S. Department of Labor, the Occupational Safety and Health Administration, and the appropriate State statutes relative to industrial safety. The applicant also should cooridinate closely with local and/or regional planning and zoning commissions to determine possible building codes and restrictions.

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GLOSSARY

1. Alkane - saturated hydrocarbon of the formula CnH_{2n+2}
2. Alkylation - a process in which a branched chained hydrocarbon is created by combining a olefin with an alkane
3. Amines - hydrocarbons containing the amine radical - NH_2
4. B/CD - barrels per calender day; annual production divided by 365
5. Benzene - cyclic hydrocarbon - C_6H_6
6. Boiling Range - the temperature range between which the middle 80% of a fraction boils
7. BTX - benzene, tolvene, oxylene
8. Butane - C_4 alkane; C_4H_{10}
9. Butylene - C_4 olefins also butene
10. Catalyst - substance which encourages a reaction but does not participate in the reaction, thereby remains unchanged
11. Catalytic Gasoline - gasoline arising from any of several catalytic processes
12. Cracking - the process of reducing long chained hydrocarbons to simplier compounds; also molecular cracking; when catalysts are used to accomplish this, the process is known as catalytic cracking; when heat alone is used, it is called thermal cracking
13. Crude Oil - petroleum directly from wells
14. Cumene - benzene derivative; C_9H_{12}
15. Cyclic Compounds - ring hydrocarbons
16. Cyclohexane - cyclic hydrocarbon; C_6H_{12}
17. Deasphalting - a process which removes the asphalt fraction from feedstock
18. Distillation - a process for dividing liquid mixtures by their boiling points; also fractionation products are known as fractions
19. Ethylene - an olefin; C_2H_4
20. Feedstocks - the petroleum material entering the process
21. Flash Separation - a process in which the feed is sent into a chamber where the lower boiling components are flashed off
22. Gas Oil - a petroleum fraction which is recovered in fractionation between kerosene and residual fuel oil (boiling range 260°C-400°C (500-750°F.)
23. Gasoline Stabilization - a process to remove low boiling fractions which tend to evaporate from gasoline
24. Heavy Bottoms - highest boiling fraction in a distillation column
25. Heavy Tapped (Crude Oil) - crude oil with highest boiling fraction removed
26. Hydrocracking - cracking in the presence of hydrogen to saturate the olefins formed in the process; catalytic hydrocracking utilizes a catalyst
27. Hydrodesulfurizing - removal of sulfur from petroleum in presence of hydrogen; similar to hydrotreating
28. Hydrogenation - the process of adding hydrogen to an unsaturated hydrocarbon
29. Hydrogen Sulfide - H_2S
30. Hydrotreating - a process which removes sulfur from oil by treating it with hydrogen to form hydrogen sulfide
31. Isobutane - branched butane isomer

32. Isomerization - the process of converting straight chained alkanes into the branch chained isomers
33. Kerosine - a petroleum fraction with a boiling range 220-275°C (430-530°F.)
34. LPG - liquified petroleum gas - contains C_3, C_4 hydrocarbons
35. Lube Oil - petroleum fraction with high viscosity and flash point of 205-315°C (400-600°F); used for lubricating purposes
36. Mercaptans - organics containing SH radical groups
37. Methane - CH_4
38. Middle Distillates - distilled products in the middle range of the fractionation column
39. Naphtha - a petroleum fraction boiling in the kerosene and light gas oil range
40. Octane Rating - percentage by volume of isooctane that must be mixed with normal heptane to match knock intensity of the fuel undergoing testing
41. Olefins - hydrocarbons containing a carbon - carbon double bond formula C_nH_{2n}
42. Overhead Vacuum - distilled gas oil. Gas oil produced by use of vacuum in distillation tower
43. Paraffins - straight chain alkanes
44. Petrochemicals, first generation - petrochemicals produced in process step from petroleum feed stocks
45. Petrochemicals, second generation -petrochemicals produced directly from first generation petrochemicals
46. Phenol - Benzene - containing alcohol
47. Phosphorous Pentoxide - P_2O_5
48. Polymerization - formation of polymers
49. Propane - C_3H_8
50. Propylene - C_3H_6
51. Reformate - product of reformation
52. Reforming - a catalytic process to produce gasoline using a series of reactions including decyclization, desulfurization, ionizationed dehhydrogenization
53. Residual Fuel Oil - petroleum fraction boiling above 750°F.
54. Steam Ejectors - use of steam to produce a vacuum in a process
55. Styrene - $CH{=}CH_2$
56. Thermal Coking - conversion of heavy feed stock to coke using high temperatures
57. Thermal gasoline - gasoline by non-catalytic means
58. Tolvene - benzene derivatives
59. Topping - distillation process which removes low boiling fraction
60. Visbreaking - a process which thermally reduces visusity